PRIVATE INDIVIDUAL SERVICES IN THE RURAL AREA

submitted to the

Regional Municipality of Ottawa-Carleton
and
Ministry of Municipal Affairs

GEO-ANALYSIS
Groundwater Consultants

J.L. Richards & Associates Limited
Consulting Engineers, Architects & Planners

PRIVATE INDIVIDUAL SERVICES IN THE RURAL AREA

Prepared For:	Regional Municipality of Ottawa-Carleton & Ministry of Municipal Affairs
Prepared By:	Geo-analysis Inc., J.L. Richards & Associates Limited
Dated:	May, 1992
Our File No.:	G9105

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May 22, 1992

Planning Department
Regional Municipality of
Ottawa Carleton
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Attention: Lesley Paterson, Policy and Programs Division

Re: Private Individual Services in the Rural Area

Dear Madam:

Geo-analysis Inc. and J.L. Richards & Associates Ltd. are pleased to submit our report on the private individual services in the rural area, in fulfillment of the terms of reference dated November 9, 1990.

Yours very truly,

GEO-ANALYSIS INC.	**J.L. Richards & Associates Limited**
Jacques J. Sauriol, M.Sc.	T. Peter Hannah, M.C.I.P.
Senior Project Hydrogeologist	Principal Project Planner

JJS/pc

engineering geology-hydrogeology-terrain mapping-remote sensing-environmental studies

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May 22, 1992

Provincial Programs and
Planning Branch
Ministry of Municipal Affairs
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Toronto, Ontario
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Attention: Bryan Hill, Manager

Re: Private Individual Services in the Rural Area

Dear Sir:

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EXECUTIVE SUMMARY

The purpose of this study is to recommend policies and practices that should be implemented to ensure safe and appropriate development on private, individual services. Cumulative, long term implications of potential development on private individual services have been paramount in drawing the study's conclusions. Those conclusions are therefore conservative. They lead to difficult decisions about our approaches to future development but these issues need to be debated openly, as part of the land use planning process.

A basis for an aquifer management system has been developed for the Regional Municipality of Ottawa-Carleton (RMOC) and Ministry of Municipal Affairs (MMA) covering the Townships within and surrounding the RMOC. The aquifer management system is the process by which all geological and hydrogeological information is assembled to generate these planning criteria to ensure sustainable development based on private individual services. A Geographical Information System (GIS) is the corner stone to organize the information for the aquifer management system. The results are summarized in the following report.

The study area is underlain by various aquifers including several bedrock aquifers, basal gravel aquifers and overburden aquifers (geological unit capable of yielding water to a well). Well yield provided on a daily basis by the underlying aquifers is in most cases sufficient to meet residential demand. Natural water quality is of potable composition in most of the study area, with randomly occurring pockets having aesthetic parameters which exceed the Ontario Drinking Water Objectives. Water of a non-potable nature is found more commonly in bedrock aquifers in the eastern one third of the study area and in selected reaches along the Ottawa River, where pockets of saline groundwater are found. Overburden sources of good quality are found locally. No widespread anthropogenic contamination in the aquifers is documented. Locally, septic system contaminant problems exist, particularly in those areas where overburden is thin and/or where the same geological unit is used as a source of water and as a sink for septic system effluent.

Present water quality guidelines for new subdivisions were developed by the Ministry of the Environment and they adequately address natural groundwater quality. However, this list could be expanded to include hydrocarbons, pesticides, heavy metals and PCB's in those areas where past or present impacting land uses are suspected.

Treatment with commercially available equipment should be restricted to one aesthetic compound exceeding the water quality objectives, provided it is within the MOE treatability limits. Treatment for several aesthetic compounds should be evaluated by an independent, qualified process engineer, who will confirm that the water is treatable and will provide a design for its treatment. Municipalities should be aware of possible future increases in these limits as technology improves.

MOE Regulation 612/84 adequately deals with proper well construction. Third party inspection of well construction is rarely completed. This has created the potential for the presence of inadequately constructed wells. Several area municipalities have attempted to control well construction by the implementation of a well compliance program, where the driller certifies that the well has been constructed according to specific guidelines. The effectiveness of these programs has not been documented. Given the importance of the groundwater resource and its susceptibility to contamination in selected areas, a well compliance program is a good first step to achieve control. It should be taken further by means of driller inspection, to ensure that proper methodologies are carried out (ie. grouting). Furthermore, many overburden wells (i.e. sand points, and dug wells) are built by non-licensed contractors and/or are not documented by a water well log submitted to the Ontario Ministry of the Environment. Regionally, a by-law should be drafted to require registration of all water wells, including any overburden wells, and submission of water quality and quantity information. Municipalities should not issue a building permit on a lot or at least not issue a certificate of occupancy without the receipt of a formal well record signed by a licensed well contractor.

Lot layout of new subdivisions and severances should ensure that:

a) The location of the well is upgradient from the lot's septic system
b) The location of the well is not directly downgradient from septic systems on adjacent properties.
c) A well is not located in an area where nitrate loading from a leaching bed plume exceeds the drinking water limit for Nitrate (10 mg/L as N).
d) The construction of a leaching bed is not directly upgradient of a neighbour's well.

Lately uncontrolled heat pump uses of the groundwater resource have increased. Further use should be investigated and legislated. Depending on the heat pump system, possible negative problems associated with heat pump use of the aquifer include the following:

a) Contamination by spill and leakage from the system.
b) Excessive groundwater demands which could mine the aquifer.
c) Mixing of varying quality water from different bearing zones, leading to the deterioration of the potable source.

Until the use of heat pumps is more carefully controlled and any negative effects are investigated, a moratorium on their installation is recommended. In the case of conflicting uses, the groundwater resource should be dedicated to water supply uses.

Recharge probability areas for bedrock aquifers have been outlined by the aquifer management system. The areas of high recharge probability are usually associated with thin overburden and bedrock outcrops, or coarse granular materials for the upper aquifers and are considered the most sensitive to contamination. Aquifers should be protected from high risk land uses, including:

a) High density sewage disposal
b) Domestic and industrial solid waste disposal
c) Uncontrolled agricultural practices
d) Industrial activity
e) Storage facilities for potential contaminants
f) Transportation corridors
g) Aggregate extraction

The MOE criteria demand that, on an individual lot, septic system effluents are not discharged onto the surface of the ground and that they do not cause impairment of the groundwater. In order to protect groundwater supplies, the best terrain for the construction of septic systems includes thick clay soils. Worst terrains consist of thin sandy soil over bedrock and surficial sand aquifers being used for the disposal of septic system effluents. Two methods of assessment are recommended in this report, a flowthrough dilution-dispersion method for permeable soils, and a hydraulic mounding calculation method for less permeable soils.

Specific recommendations include the following:

a) Mineral soil thickness in excess of 1.2 m is desirable for development on conventional Class IV septic systems. Development on private services should be restricted to natural mineral soil thickness in excess of 0.3 m. Furthermore, marginal terrain should be upgraded by importing fill material up to a minimum total thickness of 1.2 m for the leaching bed and mantle area.

b) For clays and silts, a mounding assessment should be completed. Typical lot sizes can be expected to be approximately 1.5 to 2.1 ha, unless fractures are present.

c) For more permeable soils such as sands, flow-through dispersion assessments should be completed in order to determine the extent of the potential nitrate plume.

   When the overlying sandy material is a potential aquifer, the flow through method should be completed and the size of the lot should be based on the nitrate criteria. Typical lot size will be approximately 1.7 ha for a saturated thickness of 10 m.

   When the sand has no potential for aquifer use and the bedrock is the main aquifer, the underlying stratigaphic unit should be verified. If the sand is underlain by at least 1.2 m of clay type soil, mounding assessment should be completed. Typical lot size will be approximately 1.4 ha. If the sand is underlain by less than 1.2 m of clay type soils and is mainly underlain by bedrock, the flow through assessment should be completed in the bedrock aquifer. Typical lot sizes will be greater than 2.8 ha.

Conventional septic systems do not denitrify nitrates. Until new technologies are adopted, the only solution is dilution, and large lots adequately oriented are required (i.e. long axis of lot parallel to shallow groundwater flow direction).

The basic assumption for the plume delineation assessment in permeable soil is the absence of any denitrification. In recognition of nitrate attenuation processes, smaller lot sizes could be considered in a phased development, if monitoring demonstrates occurrence of active denitrification processes. Development could also proceed with smaller lots, if determined by the monitoring of existing nitrate plumes from nearby septic systems. This approach is more conservative than that proposed by the Ministry of the Environment South Eastern Region. For lot sizes in excess of 1 ha in non-designated areas, MOE does not require an impact assessment. Lot sizes of 1 ha or less have to be justified by nitrate concentrations less than 10 mg/L at the property boundary. The MOE justification is that reasonable use concentrations of 2.5 mg/L will likely be met at the property boundary by natural nitrate reduction processes. These processes have not been documented however.

Lot sizes could be reduced with the acceptance of alternate sewage treatment systems which treat sewage to background values. The effectiveness of peat bed systems, for example are currently being tested by the Ministry of the Environment. Municipalities are encouraged to participate in the MOE programs to field test peat beds and other innovative suitable technologies in Ontario.

Review of over 200 area subdivision hydrogeological reports has been completed. This review has shown that the compliance with the minimum MOE Terms of Reference for these types of studies do not provide sufficient information for the assessment of cumulative impacts on adjacent development. The following criteria are recommended in order to more thoroughly assess cumulative impact on the groundwater supply:

a) Determine aquifer boundary conditions
b) Determine aquifer long term sources
    i.e. - leakage from upper aquifers
    - surface waters
    - infiltration
c) Determine changes in water quality due to long term pumping
d) Determine water quality from existing well users
e) Determine the effect of long term precipitation cycles
f) Determine the effect of the well spacing on the local water table (well interference)
g) Long term groundwater monitoring of quality and hydraulic head should be initiated and can be achieved by requiring developers to install a monitoring well to be donated to the municipality or a system permitting any well to be sampled anytime.

Additional suggestions on cumulative impact:

- Where proposed lot sizes differ from the recommendations of this report, phased-in development with extensive monitoring should be required.
- Contiguous development should not occur until existing development has demonstrated that no adverse effects have taken place.
- The RMOC and MMA should initiate a compilation of new well records and subdivision studies for inclusion in the aquifer management system.

Planning implications of the introduction of strong groundwater protection goals in the rural planning process raise fundamental questions about land use policy conflicts:

- Many rural municipalities have Official Plans designating agricultural lands, mineral aggregate areas, flood plains and wetlands as resources to be protected. The remaining marginal resource lands, which are under high pressure for development on private services, are also marginal in their hydrogeologic potential to sustain development.
- Many of the best development lands are the better agricultural lands.
- Aggregate extraction can negatively affect groundwater recharge and water quality.
- The extraction of peat for peat beds conflicts with wetland preservation.
- Settlement patterns and rural land consumption approaches need to be re-evaluated.

Septic system impact assessments have not been required by the MOE. Contaminant loading for a typical individual septic system should be addressed for the site specific conditions as part of the determination of the cumulative impact. In addition, mounding computations should be completed for leaching beds proposed on clay or silt. The following items should typically be included in a cumulative impact assessment:

a) Nitrate loading to the shallow groundwater aquifer on and off site

b) Other contaminant loading to the shallow groundwater and surface water (if applicable)
c) Determination of flowpaths of contaminant prior to the development and after development
d) Mounding calculation
e) Determination of the appropriate lot size based on the most restrictive design criteria (i.e. mounding or nitrate loading)

The cost of groundwater clean up programs are huge. Prevention is the only realistic alternative, justifying caution in the use of the resource.

The lot sizes estimated in this report virtually eliminate the concept of concentrated (0.2 ha lots) hamlet development on private individual services.

The lot sizes estimated in this report will also affect the economic viability of some rural residential development:

- Wider lots on impermeable soils as a result of mounding calculations result in more road per lot.
- Vastly deeper lots to accommodate nitrate plumes in permeable soils create major design constraints.

The successful integration of groundwater preservation goals into rural land use planning requires consideration of alternatives to scattered, privately serviced development such as new serviced communities. This will require more effective provincial leadership and assistance to municipalities.

This report recommends more thorough hydrogeological investigations for subdivisions but there is no technical reason why inferior lots should be created through the consent (severance) process.

ACKNOWLEDGEMENTS

This report was produced with pride by a group of dedicated and keen individuals. Special thanks to Berend Jan Velderman for the preparation of the draft document and for the provision of editorial comments. Special thanks to Alex Diamantopoulos for the generation of the GIS figures, to Manon Rodrigue who provided the hydrogeologic simulation of the impact assessment and to Pina Campagna for the typing of the manuscript and of several edited versions. Special thanks to the Planning/Engineering team including Daphne Wretham, Fernando Ribas, Tom Kent, Bruce Finlay and Jake Dick for their input to the text.

Special thanks to the RMOC and MMA for asking "the right question" and for the privilege of allowing us to tackle it.

1.0 INTRODUCTION

1.1 General

In 1981 groundwater was relied upon by 26% of the Canadian population for domestic use. Rates range from 1% in the Northwest Territories to 100% in Prince Edward Island. In Ontario the figure is 23% (Environment Canada, 1990). In the United States, the figure rises to 50% (Dr. David Rudolph, University of Waterloo), again varying considerably across the nation. With a population ten times as large as Canada's, valuable experience has been gained and lessons learned, much of which can be used to assist Ontario jurisdictions in avoiding the same mistakes. European experience is also valuable.

Some parts of Ontario are far more dependent on groundwater for domestic consumption than Ottawa-Carleton and the surrounding Townships. The Regional Municipality of Waterloo has a population of 350,000 which is entirely dependent on groundwater. If supplies are not protected a piped supply from Lake Huron is a probable alternative. Attention has recently been focussed on the Town of Elmira where contamination from the Uniroyal plant has a projected clean up cost of $100 million and may take 30 years.

Although Ottawa Carleton and surrounding area is far less dependent on groundwater, there is no reason for complacency. If care is not taken to protect this natural resource, the per capita cost of remedial measures and clean up is far greater for dispersed land use activities which are dependent upon groundwater.

Some problems have already begun to appear, requiring expensive solutions. The extension of sewage services and the development of a communal water supply for Carp is an example. The recent discovery of groundwater contamination in Manotick is another. The Regional Official Plan's policy of requiring hydrogeological evidence to support village and hamlet expansions is a good starting point but further, more analytical consideration of groundwater issues needs to be incorporated into the decision making process for rural land use in general.

It is interesting to note that even the traditional users of the rural land base, the agricultural community, are becoming concerned about this issue. There are few choices for farms with poor groundwater if they aren't located beside a lake or river. The Ontario Soil and Crop Improvement Association began a systematic survey of 1340 wells in the fall of 1991, to be completed by the summer of 1992, sampling for pesticides, bacteria and nitrate.

The first step in the development of a long term groundwater protection strategy is the compilation of a data base and an understanding of current conditions, constraints and opportunities. This study is that first step.

1.2 This Study

Rural residential development based on private services (septic systems and wells) has experienced a large growth in the past few years in the Regional Municipality of Ottawa Carleton (RMOC) and abutting Townships. Because of concerns about sustainable growth on private services, the RMOC and Ministry of Municipal Affairs (MMA) have undertaken this study to evaluate the potential for safe growth in the rural areas. In order to ensure sustainable development on these natural resources, a basis for an aquifer management system has been developed by Geo-analysis Inc.. The aquifer management system has been used to compile existing data and outlines areas where development should be encouraged and areas where development should be discouraged.

With the aid of the aquifer management system, the study area was examined and evaluated in terms of its suitability for growth on septic systems and groundwater supplies. The study is not meant to replace in depth, site specific studies. The study database allows for an assessment of hydrogeological trends in the study area. Recommendations on what issues site specific studies should address, in excess of the MOE Guidelines for hydrogeological studies, have been defined.

The study area includes the following 21 municipalities (Figure 1a):

Beckwith
Cambridge
Clarence
Cumberland
Gloucester
Goulbourn
Kanata
McNab
Montague
Mountain
Nepean
Osgoode
Oxford-on-Rideau
Pakenham
Ramsay
Rideau
Russell
South Gower
West Carleton
Winchester
Wolford

The urban area centered around Ottawa has been excluded.

1.3 Methodology

Existing information was used to arrive at recommendations on policies and practices that should be implemented to ensure safe and appropriate rural development on private individual services. The study team created an aquifer management system to organize and analyze this information. A Geographic Information System (GIS) is the tool that has been used to assimilate the information.

Activities completed to arrive at the aquifer management system included:

- Review of published geologic maps and reports
- Review of 200 available hydrogeologic reports completed for subdivision submission
- Review of 21,000 water well records.

Based on the above information, a relational data base was created using the GIS to outline the geological and hydrogeological characteristics. These items included a compilation of aquifer type, relative recharge probability, typical well yield, level of groundwater chemical composition, terrain type, overburden thickness, bedrock surface topography, estimated hydraulic conductivity of the overburden materials, groundwater flow direction and an estimate of capture zones.

The above information led to the formulation of an opinion on relative aquifer suitability and terrain suitability for private services. Based on the outcome, a series of recommendations has been proposed.

1.4 About This Report

This report deals with a series of issues outlined by the Regional Municipality of Ottawa Carleton and Ministry of Municipal Affairs on the technical aspects of private individual services in rural areas. This report consists of the following sections:

- Aquifer Management System
- Water Quality
- Water Quality Distribution
- Well Construction
- Aquifer Recharge
- Private Sewage Disposal
- Cumulative Impact and Distribution of Rural Development
- Rural Development Policies

To assist in identifying the location of features on the provided 8 1/2 x 11 figures, the reader is referred to a transparent hydrologic and cultural overlay found in the back pocket. A bibliography is provided in Appendix E.

2.0 AQUIFER MANAGEMENT SYSTEM

2.1 Introduction

An aquifer management system was developed for the study area. The aquifer management system incorporates a process by which all geological and hydrogeological information is assembled to generate planning criteria in order to ensure sustainable development based on private individual services. It is composed of an outline of the geologic setting and of the hydrogeologic setting. The distribution of the aquifers is displayed cartographically.

Good aquifers include the sandstone and carbonate formations, as well as thick coarse grained non-consolidated deposits. Well yields are generally good for private individual well water supply purposes.

Groundwater quality distribution varies within the study area. Additional information on the aquifer management system is found in other sections of this report including flow systems, recharge probability, terrain suitability and development potential.

Geo-analysis has provided the information base in electronic file to MMA and the RMOC under separate cover.

In order to update this record, a filing system should be established to collect all water well records since 1985 and keep a record of all subdivision reports. This record keeping in the future could also include sampling of the monitoring stations.

From these reports, the items listed, as provided by Geo-analysis Inc., should be extracted and periodically integrated with the database to provide an updated map.

2.2 Physiography and Surficial Geology

The Regional Municipality of Ottawa Carleton and surrounding Townships study area is bounded to the north by the Ottawa River. The western part of the study area is composed of the Algonquin Highlands physiographic region (Chapman and Putnam, 1984) (Figure 2a). This area is characterized by rough ridges of granitic rocks with generally coarse grained overburden materials. Locally, significant thicknesses of this material may occur.

A larger part of the study area, to the south-west, is covered by the Smith Falls Limestone Plain physiographic region (Chapman and Putnam, 1984). The area stretches from West Carleton Township to Wolford Township. This area is characterized by outcropping flat-lying limestone overlain in places with shallow soils of various types. Locally, in this region faulting has allowed deposition of clay of significant depth. The shallow soils in this region are usually characterized by high water tables. This is evident from the numerous wetlands found in the area.

The central and eastern portions of the RMOC and abutting Townships are generally characterized by sand plain, clay plain and drumlin field physiographic regions (Chapman and Putnam, 1984). Typically, the overburden is deeper than that found in the western part of the study area. Most of the deposits found in the eastern part are of glacial and marine origin. Locally where the Champlain Sea deposits have been eroded, the glacial till is exposed. The clay plains are found along the Ottawa River, predominantly in the Townships of Cumberland and Clarence. The sand plain and drumlin regions are found south of the clay plains. In most of this part of the study area, the clays and sand are underlain by till.

2.3 Drainage

The Ottawa River is the main river in the study area. The glacial history has disrupted the drainage pattern in the area resulting in numerous poorly drained areas. Other main rivers in the study area are the following: the Mississippi, the Carp, the Jock, the Rideau and South Nation Rivers.

2.4 Bedrock Geology

In eastern Ontario, the bedrock ranges from Precambrian age to Late Ordovician age. Typically, to the east of the "Frontenac Axis" (Precambrian Shield Bedrock) the geological formations are younger. Associated with this trend to the east, a change in the lithology is also noted. The sequence changes from granitic and meta-sedimentary rocks of Precambrian age, through sedimentary rocks comprised successively of sandstones, dolomites, limestones, and shales of Cambrian and Ordovician ages. Karst features have been reported in some of the limestones and dolostones. The units are of highly variable thicknesses because of faulting, and inter and post-depositional erosion.

The sedimentary bedrock strata are generally flat-lying with some tilting and folding near fault boundaries. The bedrock stratigraphy of the study area is shown in Table 1.

The area is significantly affected by faulting, which has altered the distribution of the formations. The Gloucester, Hazeldean and Orleans fault zones are the main controlling fault zones (Figure 3) with up to 480 m of vertical displacement.

2.5 Bedrock Aquifers

The lithology and fault zones discussed in the previous section act as the controlling factor in the distribution and quality of the aquifers in the study area. (Sobanski, 1969).

The following is a listing of bedrock aquifers and their characteristics. The upper hydrostratigraphic units are shown in Figure 4a.

2.5.1 Precambrian Aquifer

The Precambrian aquifer consists of igneous and metamorphic rock (Figure 4a, Table 1). A water supply developed in the Precambrian rock is highly variable. It's productivity is mainly controlled by secondary porosity (i.e. fractures). In extensively fractured areas, the potential for large volume yield is good. However, subdivision reports indicate that more commonly, the transmissivity is low, with yields barely meeting domestic supply requirements. Furthermore, drilling to greater depth will generally not increase well yields. The water quality from the predominantly granitic aquifer is highly variable, commonly increasing in mineral content with depth. Also, areas of elevated mineralization and sulphur occur randomly alongside areas of good water (Brandon, 1960: Sobanski, 1969).

2.5.2 The Nepean Formation Aquifer

The Nepean Formation consists of sandstone (Figure 4a, Table 1). The Nepean Sandstone has the highest yields of the bedrock aquifers in the area. Yields are well in excess of the domestic requirement. The Nepean Formation is utilized in the area bounded by the Hazeldean and Gloucester faults. However, it is believed to underlie many of the other areas at greater depth (Sobanski, 1969). The Nepean aquifer is best developed near the top and the base of the Formation (Brandon, 1960). The water quality of the Nepean Formation is generally of very good potable quality in most areas with occurrences of elevated iron in places. Sobanski, (1969) reports that in areas where the Nepean Formation lies at great depth, such as near the City of Ottawa and East of the Gloucester fault, yield from the aquifer is low.

2.5.3 March and Oxford Formation Aquifer

The March and Oxford Formations aquifer consists of dolomite and limestone (Figure 4a, Table 1). The March and Oxford Formation aquifer can be considered one hydrogeologic unit as their lithologies consist mainly of dolostone and are hard to distinguish in the drillers water well records.

Yields from the aquifer are known to be highly variable. Sporadic dry holes have been drilled in this aquifer. It is quite common to find poorly producing wells immediately adjacent to wells producing good yields in this aquifer (Sobanski, 1969). The water quality in this aquifer is generally acceptable for consumption, although it has high levels of hardness in places. Local variations of elevated iron content, high mineral content and sulphide odour may occur (subdivision reports). Larger yields have been reported in groundwater discharge areas (Sobanski, 1969).

2.5.4 Rockcliffe, Verulam, Gull River Formation

The lower part of this aquifer (ie. Rockcliffe) generally consists of limestones and shales (Figure 4a, Table 1) and has yields which are just sufficient for domestic purposes. It generally yields water of potable quality. In the eastern part of the study area the Rockcliffe Formation may yield water quality of poor potability. The aquifer is utilized where the

Oxford and March Formation are at greater depth. The upper part of this aquifer (ie. Verulam to Gull River) predominantly consists of limestone with lower transmissivity and has generally variable well yield.

2.5.5 Lindsay, Eastview, Billings, Carlsbad, Russell and Queenston Formations Aquifer

The Lindsay, Eastview, Billings, Carlsbad and Russell Formations consist of shale and limestones (Figure 4a, Table 1). The Queenston Formation consist of red shales (Figure 4a). These Formations exhibit poor well water yields. The water quality usually is poor with mineral content in excess of the MOE guidelines.

2.6 Overburden Aquifers

In the Regional Municipality of Ottawa-Carleton and in the surrounding Townships, non-consolidated sediments are of Pleistocene and post-Pleistocene Age. These sediments are of glacial, glacio-fluvial, marine and fluvial origins (Figure 2b). In some localities, the thickness of this overburden exceeds one hundred metres.

Selected deposits form locally excellent aquifers, in particular in those areas where vast quantities of saturated coarse grained deposits occur. Pumping in these aquifers has shown that good potential for a long term potable water supply exists. However, testing in these aquifers has also shown that areas of poor production occur near areas of good production. Furthermore, the fact that the MOE water well records with regards to overburden aquifers is incomplete, creates difficulty interpreting their extent and the potential utilization of the overburden aquifers. Generally, these aquifers are associated with the following coarse grained deposits:

a) Deltaic and estuarine deposits
b) Ice contact stratified drift
c) Basal gravel till (coarse grained deposit top of bedrock surface).

Figure 4b shows the distribution of the deposits. The deltaic and estuarine deposits are most widely utilized for individual domestic water supply in the Eastern part of the study area. Typically in this area, the overburden aquifer is the only available source of potable water of acceptable quality. The proximity to the ground surface of this aquifer makes it susceptible to contamination. This contamination has been particularly noticable in villages, where this geologic formation is the sole source for water supply and also serves as a sink for septic system effluent disposal.

The ice contact stratified drifts are found in a series of north-south trending linear deposits throughout the area. Well known deposits are the Sarsfield-Morewood esker complex, the Bowesville moraine and the Stittsville-Kars esker. The sinuous and narrow nature of these deposits offers a water supply of local importance only. Conflicting land uses near these deposits such as aggregate mining and garbage disposal quite often endanger the utilization of this excellent source of groundwater.

The basal gravel till is present at the interface between the glacial till and the bedrock surface, and is widespread throughout the study area. In many localities it provides a reliable water supply of good quality. The presence of the basal till aquifer is often not recorded as drillers frequently by-pass this water supply. Furthermore, this aquifer may be utilized by many home owners unknowingly as drillers retract the casing slightly to utilize this resource in the event of lack of water in deeper zones. This aquifer occurs most frequently in bedrock valleys and is of good quality in most locations. The exceptions are those areas where the aquifer is overlain by thick sequences of marine clays or is underlain by shales. These deposits typically have elevated sodium chloride content.

Figure 4b also outlines the distribution of alluvium and nearshore sediments. Most of these units have too limited saturated thicknesses to offer any significant potential.

3.0 WATER QUALITY

This section provides a review of the existing water quality guidelines. The purpose of the review was to ascertain their applicability to the study area.

3.1 Existing Water Quality Guidelines for Subdivision Approval:

In Ontario, drinking water objectives have been designed primarily for the protection of public health. These objectives are generally intended for municipal and/or private communal water supplies (i.e. water systems serving more than five private residences). However, these objectives also state that it is desirable that the water quality of private supplies should not be inferior to that of public supplies. A subset of these guidelines are used by the Ontario Ministry of the Environment in the "Guidelines for New Subdivision Developments on Private Services" (October 29, 1990). A list of these parameters is provided in Table 2. Organic compounds and other contaminants (e.g. heavy metals) were not made part of the list as they are not a widespread problem with the exception of some suspect areas where these compounds are handled. It is the Ministry of Environment's opinion that it is up to the consultant that does the hydrogeological assessment of the proposed development to assess if there is the potential of these compounds to be present. If so they should be analyzed and included in the assessment.

Both health related and aesthetic quality parameters are included in the subdivision list. The subdivision list of Ontario Drinking Water Objectives for health and aesthetic parameters has to be satisfied in order for a subdivision proposal to be viewed favourably by the MOE for approval. If the health parameters are not satisfied, the MOE will recommend against the approval of the subdivision. If the health parameters are satisfied but there are problems with the aesthetic quality, treatment of the water within specified limits can be considered as a possible remedy to improving the quality. Favourable consideration of the subdivision in this situation will be dependent upon the decision of the Local or Regional Municipality to share the responsibility for ensuring the formulation and carrying out of the terms of the subdivision agreement (i.e. notice for the provision of treatment system and/or water quality information).

Treatment limits established by the MOE are shown in Table 2. Communal or individual treatment systems can be considered. If individual systems are to be utilized and the concentrations of the aesthetic parameters exceed the limit considered treatable, the approval of the subdivision will not be recommended. For communal treatments, a communal water supply would be utilized and the approval would then be based on requirements for water works as defined under the Ontario Water Resources Act.

3.2 Comparison With Other Water Quality Guidelines:

The MOE objectives for water quality for subdivisions were compared with limits set by the United States Environmental Protection Agency (USEPA), the European Economic Community (EEC) and the World Health Organization (WHO). These values have been provided in Table 3. The limits from the other organizations have been established for public supplies and not necessarily for subdivisions with individual wells.

3.2.1 Guideline Definitions

In this comparison it is important to understand that different organizations use different terms for their water quality limits. The type of limit establishes the purpose as well as the stringency of it. The following section outlines in general terms the type of limits used by each organization but details have been omitted on the rationale for their establishment.

The health parameter limits of the MOE subdivision list are Maximum Acceptable Concentration (MAC) limits whereas the aesthetic related parameters are Maximum Desirable Concentrations (MDC). As discussed above, the exceedance of a MAC is grounds for the rejection of the subdivision whereas exceedance of a MDC does not necessarily indicate rejection as long as the level is below the Maximum Concentration Considered Reasonably Treatable (MCCRT).

The USEPA provides drinking water regulations, proposed limits and health advisories. The USEPA values provided in Table 3 are Maximum Contaminant Levels (MCL) which are defined as a lifetime limit at the lowest practical level of a substance representing a potential hazard to humans in order to minimize the amount of a toxicant contributed by water, particularly when other sources such as milk, food or air are known to represent the major exposure to humans. The USEPA also has Secondary Maximum Contaminant Levels (2nd MCL) which are limits for aesthetic parameters and which are not enforceable.

The EEC has 3 types of standards; the Maximum Admissible Concentration (MAC), the Minimum Required Concentration (MRC) and the Guide Level (GL). The MAC term is neither defined nor is any interpretation or application provided. For this study, EEC-MAC were used for the health related parameters and for the most part GL were used for the aesthetic parameters.

The World Health Organization provides Guideline Values (GV) for drinking water quality and these values represent levels which ensure aesthetically pleasing water and will not result in any significant risk to the health of the consumer.

3.2.2 Discussion

The limits from the other organizations are generally no more stringent than the MOE objectives. The health related parameters are similar for all organizations. The fluoride value varies from 1.5 to 4.0 mg/L. The MOE value is in the middle at 2.4 mg/L. The turbidity value for the MOE is lowest with a value of 1 NTU; the others vary from 1 to 5 NTU.

The aesthetic parameters show more variability. For total dissolved solids, hardness, and colour, the MOE limits (including the treatability limit for colour) are more stringent than the criteria from the other organizations. For iron, manganese and phenols, the maximum desirable concentrations are less stringent than the other groups' criteria.

3.3 Possible Modifications to Existing MOE Water Quality Guidelines:

The concentration guidelines for health related parameters were established by experts in the field of human health. For this reason we do not recommend any changes to these limits.

The limits for the aesthetic related parameters were set primarily on predefined perceptions of what is aesthetically suitable for private water supplies. For the new Maximum Concentrations Considered Reasonably Treatable, these limits are based on current technologies. As new treatments are developed or old ones modified, the maximum treatable concentration will be increased and other aesthetic parameters will become treatable. For this reason, it is proposed that the aesthetic parameter guidelines should be set as interim criteria. With the encouragement of the development of new treatment technologies, these limits could be reviewed and possibly revised on a regular basis.

3.4 Recommendations

When a groundwater source meets the health related parameters but the aesthetic parameters fall short of meeting the Ontario Drinking Water Objectives, it is recommended that it be accepted only if one parameter lies in the treatability range. Experience has shown that when more than one parameter exceeds the limit, treatment interference may occur with commercial units. Even if no treatability limits have been set for hardness and sodium, it is recommended that their presence be accounted for in the treatment assessment. A technical review of treatment systems must be performed for each individual case where more than one parameter falls in the treatability range. The rationale pertains to their ability to perform on a long term basis with low cost and simple maintenance. This performance review should be completed by qualified process engineers and will require written assurance of reliability with a bench test treatment.

In areas with a high potential to be affected by industrial or farming activities, it is recommended that the drinking water guideline list be expanded to include the following: pesticides (from ODWO list), volatile organics (from USEPA list) and other inorganics (from USEPA list).

Septic tank cleansers such as TCE contribute organic solvents to groundwater supplies. Like in some northeastern U.S., TCE based solvents used as cleansers for septic systems should be prohibited in the study area.

4.0 WATER QUALITY DISTRIBUTION

4.1 Groundwater Chemical Composition

The compilation of water well records has shown that the general groundwater flow direction is easterly in the bedrock aquifer. This flow is affected locally by fault boundaries and geological contacts. The geological information for the study area shows that the bedrock geology in the study area gets progressively younger going east, and the lithology changes from sandstones, to carbonates, to shales.

As the shale content increases, so does the mineral content of the water supply. The concentration of total dissolved solids changes abruptly with the crossing of fault boundaries suggesting little connection between fault blocks, (eg. Gloucester Fault; Geo-analysis Inc., 1984 the Village of Russell) (Sobanski, 1969).

The areas which have a higher potential to be of poor water quality in the bedrock due to shales have been shown in Figure 4a. Discussions with local drillers indicate that in these poorer quality areas, the least mineralized water will be found at shallow depths and that deeper drilling will only yield more saline waters.

Geo-analysis Inc. experience has also shown that Villages which solely depend on the bedrock aquifer through individual and communal services are experiencing a progressive increase in mineralization of the water quality with time (eg. Kemptville, Richmond). This is also occurring in the better performing aquifers. The origin of this salinization is not completely understood, but possible sources include: 1) upconing of deeper mineralized waters is occurring through excess use; 2) pumping alters the chemical balance of the aquifer and; 3) pollution from road salting and septic systems is affecting the aquifers.

Areas of poor water quality can also be found in groundwater discharge zones. These areas are usually found in the lower reaches of river drainage basins and largely depend on flow path distance since mineralization increases with contact time with the host rock. Areas that could fit this description in the study area are the north half of Cumberland Township, north half of Clarence Township, eastern portion of West Carleton Township, lower reaches of the Rideau River, and the Mer Bleue Bog.

Areas of mineralization may occur where the Precambrian Formation is the main aquifer. Many areas of the Precambrian rocks produce good quality water. Where flow is restricted, mineralized water may be present. Such occurrences appear to be localized (Sobanski, 1969).

The water quality distribution is illustrated in Figures 5a and 5b, showing chloride and alkalinity, based on the subdivision study reports. The maps were generated by a surface interpolation method known as "Potential Mapping" and used primarily to illustrate trends. Potential Mapping uses a linear weighting function for each data point over a 5 km radius. These figures also show the incomplete coverage of subdivision reports. Based on the subdivision information and geological background, Geo-analysis Inc. has assigned a water quality composition to each aquifer in Figures 4a and 4b. It is expected that on the regional scale, these compositions will be valid. Local confirmation should be conducted.

4.2 Anthropogenic Impact on Water Quality

In order to address the present anthropogenic (ie. man induced) impact on the water supply, the Health Unit directors in the Region and abutting Townships were contacted. Also, the Ministry of the Environment Offices in Ottawa and Kingston were contacted. In response to a request to indicate areas where problems exist or where problems had occurred, we were told that most problems had been alleviated and solved. Only the Leeds, Grenville and Lanark District Health Unit and the Eastern Ontario Health Unit indicated problem areas. Geo-analysis Inc. is aware of selected nitrate problems in the study area (Figure 6), however, this list may be far from complete. No complete regional water quality surveys exist to document the complete state of the groundwater supply. It is felt that there is the potential of serious undocumented water quality contamination in parts of the study area.

Problems reported to the MOE and Health Units generally include:

Elevated Nitrate,	which is attributed to septic system impact, although in some instances may be due to agricultural activities.
Elevated Bacteria,	which is attributed to septic system impact.
Elevated Salt,	road salting activities or natural background of aquifer.
Hydrocarbon Contamination,	leaking underground storage tanks, heating oil, etc.
Organic Solvents,	septic tank cleaners (eg.TCE).

These problems are particularly aggravated in areas of thin overburden, and where the surficial unit is utilized as the aquifer.

4.3 Recommendations

Areas with groundwater quality deficiencies as oultined by Part VIII Directors are shown in Figure 6. The water quality distribution outlines localized poor groundwater quality which varies over a short distance. The outlined areas are based on incomplete information. An extensive water quality survey of existing wells should be undertaken in order to obtain a more complete view of this issue.

5.0 WELL CONSTRUCTION

5.1 Well Construction

Well construction in Ontario is regulated by MOE Regulation 612/84. Regulation 612/84 stipulates well construction techniques and regulations to protect the safe-use of the groundwater resource. The MOE South Eastern Region enforces this regulation reactively. That is the MOE will respond to complaints of possible violation with an investigation. A proactive enforcement would be desirable. The reactive level of control has likely resulted in unnoticed improper grouting and casing installation in some wells by drillers. One improperly completed well in a densely developed subdivision normally goes unseen for years until damage to the aquifer has occurred.

The Regulation furthermore requires that, with the construction of each well, the installer is to complete a well record. This system works fine for wells completed in the bedrock, however for some reason not all completed overburden wells are registered. This pertains mostly to the overburden wells that have been constructed by other methods than drilling. A scatter plot of the bedrock wells and overburden wells in the Ministry records (Figures 7 and 8) reveals that in some areas of known overburden aquifer utilization, no water well records are available. One such area is found in Cambridge Township, where numerous sandpoints are installed and no well reports are found.

5.2 Heat Pumps

The Executive Director of the Canadian Earth Energy Association indicated in late 1991 that 22,500 earth energy systems have been installed in Canada since 1979, as many as 1,000 in the Township of West Carleton alone.

Groundwater heat pumps require a large flow either through pumping or heat exchange by brines or methanol. This flow is typically equivalent to 3 times the flow for a domestic supply. The present method of heat pump installation does not control or monitor the water quality before and after the installation.

The large volume requirements encourage the deepening of wells, with the intersection of several water bearing zones, promoting the mixing of varying quality groundwater and the possible contamination of potable upper zones.

In addition, water quality changes due to aeration caused by some heat exchangers, the potential for contamination for coiled based equipment (eg. brines and methanol), temperature changes and increased water demand stress on the aquifer, are suggested as issues for future investigations. Ontario Hydro and MOE should cooperate to regulate this conflicting use of the groundwater.

5.3 Well Compliance

In order to control well construction, some area municipalities have adopted well compliance Regulations. The driller and homeowner sign a document to confirm that the well has been drilled according to the Township's Regulation. All municipalities with such a program report a low cost of record keeping and a good response rate. However, no field control of well construction compliance is conducted. (Appendix B lists the area municipalities response concerning Well Compliance Regulations).

5.4 Recommendations

The sustainability of development based on private services depends upon the control of well construction techniques. It is recommended that more inspections of well construction be conducted with emphasis on grouting (i.e. ensuring complete circulation of the grout mixture in the annular space, bottom upwards) and proper casing installation. A minimum of 6 m of grouted casing should be used. No need for additional requirements is deemed necessary since lot size will control cumulative impact.

A moratorium on the use of groundwater heat pumps should be put in effect until controlled and regulated. Furthermore it should be ensured that groundwater heat pump use will not adversely affect potable water quality. This could possibly be achieved by a control on water quality of all water bearing zones and the bypassing of drinking water supply zones. Furthermore it should be assured that the systems utilized for heat pump use can not introduce foreign compounds into the groundwater.

Lot layout in all development should ensure that the location of wells is:

a) upgradient from the lot's septic system
b) outside the 10 mg/L nitrate plume
c) not directly downgradient from an adjacent property's septic system.

The completion of a well with an adequate supply of potable water should be included as a condition of all consent approvals which create new building lots. The one year period to prove this capability before the consent lapses is more than adequate. An unsuspecting purchaser should not be burdened with the responsibility of finding potable water after the deed for a new lot has been stamped.

6.0 AQUIFER RECHARGE

6.1 Water Quantity

Review of the 200 subdivision reports shows that at each proposed subdivision, a water demand of at least 2250 L/day per lot can be met. However, this yield does not take into account the cumulative effect of each subdivision on the regional aquifer potentiometric surface. High density development may be restricted by cumulative well interference demanding larger lots. The Regional Guidelines for hydrogeology studies for Village Expansions should be followed for high density well uses (eg. contiguous subdivisions, Hamlets or Villages). An example of a map which demonstrates cumulative hydraulic impact of development on the bedrock aquifer under Richmond is provided in Figure 10.

Isolated reports of dry wells have been reported and appear to occur mostly in the limestone of the Chazy Group. It is suspected that isolated dry wells can be found in any bedrock formation. MacLaren (1970) and Sobanski (1969) report no areas of water quantity problems. Based on the existing information, no wide spread water quantity problems appear to exist.

6.2 Bedrock Aquifer Recharge Areas

Sobanski (1969) used the streamflow data at Spencerville in the South Nation River basin baseflow to characterize the recharge to the aquifer. Based on his calculations the average recharge rate in the South Nation River Basin was estimated to be low (varying from 19,300 to 70,200 gal/year per square mile) . He questioned the accuracy of the derived values, but supported his finding with recharge studies from similar areas.

Studies since then completed by Geo-analysis Inc. have shown that complex recharging processes take place which contribute to the aquifer flow in Ottawa-Carleton and adjacent Townships. Detailed studies of selected drainage basins (e.g. Greens Creek, and part of Jock River basins) in the study area have shown that the bedrock aquifer groundwater drainage basin is semi-independent from the surface drainage basin. The bedrock groundwater drainage basins appear to underlie several surface water divides in the study area. This however does not mean that the connection between the surface water and aquifers is not important in the water budget. The aquifers are the main contributer to stream flow in the later summer. The numerous wetlands in the western and southern part of the study area are expected to play an important role in the replenishment of the aquifers.

In some local recharge areas (e.g. north of Dunrobin), saline waters occur in the upper bedrock aquifers. These may suggest the presence of old stagnant groundwater, low hydraulic gradients, little flushing and slow groundwater turnover times.

A Geo-analysis Inc. (1990) in depth study utilizing the numerical model MODFLOW for the Village of Richmond illustrated that much of the water pumped in the Village of Richmond from the bedrock aquifer originated from leakage of the overburden, and that very little bedrock aquifer groundwater flowthrough occurred from upgradient areas. The situation in the Village of Richmond likely applies for much of the study area, and emphasizes that recharge of bedrock aquifers is not restricted to areas of bedrock outcrops.

Though poorly documented, the basal gravel aquifer appears to play an important role for the water supply in the Regional Municipality of Ottawa Carleton and surrounding Townships. From personal communications with drillers, it is known that this unit underlies vast areas and is generally a good supplier of water to wells. The likelihood of this aquifer being a good producer increases in locations where bedrock valleys exist (Figure 9). It is not uncommon for drillers to drill in the shallow bedrock, and when little water is found to retract the casing to tap the basal gravel. The well log will then be recorded as bedrock and the basal gravel is not identified. In addition, it is quite likely that many wells actually completed in the bedrock aquifer get part of their water supply through leakage along a poorly sealed casing from the basal gravel aquifer.

Review of Figures 5a, 8b, 9 and 12 generated by the aquifer management system yields several clearly definable patterns in the hydrogeology of the study area, including the potentiometric head of the bedrock aquifer decreasing from the west to the north east; mineral contents maximized along the Ottawa River; and overburden thickness increasing to the east. This pattern could lead to an oversimplified interpretation of flow pattern with main recharge to the aquifer taking place to the west of the study area and discharge occuring along the River Valleys.

Based on the available information, bedrock aquifer groundwater flow patterns are controlled by the main fault systems confined to aquifer flow blocks. The main flow blocks can be identified in the regional picture (Figure 4a). These flow blocks are composed of the various aquifers discussed in Section 2.4.

Five main flow blocks could be identified, four are mainly bounded by major fault zones and one is defined by the boundary between the Precambrian and Paleozoic lithologies. Likely, these major flow blocks are further subdivided by smaller subblocks as numerous smaller faults exist in the study area. Some of these major faults may have cut off some of the deeper aquifers from their area of recharge (Brandon, 1960) (eg. Nepean Formation east of The Gloucester Fault).

The five main flow blocks, from west to east are (Figure 4a; Figure 8b):

1) The Precambrian igneous rocks in the west bounded by the start of the Paleozoic sequence.
2) The Palaeozoic sequence north of the Hazeldean Fault and south of the Gloucester fault.
3) The Palaeozoic sequence south of the Hazeldean Fault.
4) The Palaeozoic sequence between the Gloucester Fault and the Orleans Fault.
5) The Palaeozoic sequence north of the Orleans Fault

The major flow trends in each block based on the potentiometric head have been identified in Figure 8b.

6.2.1 Precambrian Aquifer

Recharge areas in the Precambrian shield area are mostly associated with elevated ground surface topography, with discharge areas near the valleys. Most of the wells are completed in the top 40 metres of the granitic rock surface. With deeper wells, the likelihood of more mineralized groundwater increases. Flow paths in the aquifer are normally short and shallow, and have a jagged pattern due to secondary porosity (fractures) of the Precambrian Formation.

6.2.2 Paleozoic Aquifer Blocks

In the Paleozoic bedrock flow blocks, recharge will definitely occur in those areas where bedrock and other permeable materials are at the surface. The recharge potential is particularly high in those areas where the potentiometric surface of the aquifer is below the bedrock surface. The bedrock aquifer groundwater recharge probability map is provided in Figure 14. The methodology used to derive this Figure is provided in Appendix G. Flows will be from the areas of high potential to the areas with low potential, eventually draining in the many rivers cross cutting the study area. Flowing wells as demonstrated by the aquifer management system (Figure 15) confirm this flow pattern, with many flowing wells occurring along river valleys.

The distribution of water quality does not appear to be dependent on the groundwater flow pattern. Groundwater chemical composition is more directly related to lithology. The chemical composition of the groundwater in the Paleozoic blocks does not appear to change from recharge to discharge areas. This suggests that during the flow path from recharge to discharge area, replenishment from above with fresh water is occurring. The chemical composition of the water in the area between the Gloucester and Orleans faults is mineralized due to the nature of the lithology.

6.3 Surficial Overburden Aquifer Recharge Areas

Major surficial overburden aquifers have been outlined by the aquifer management system (Figure 4b). These outlined aquifers have been based on surficial geology mapping by Richard (1959-1984). Because of the coarse grained nature of those formations, infiltration rates are typically high (15 to 25 cm/year) and recharge conditions can be expected whenever they outcrop at the surface. A typical example of hydraulic conductivity distribution, velocity distribution and well capture is provided in Figure 11 for a sand aquifer, using Flow-path numerical code. Typically a very long and narrow capture zone can be delineated for each well. Any high risk land use activity located within such a capture zone would have a direct impact on the well water quality.

6.4 High Risk Land Uses

In principle the entire influence area around a drinking water supply should be protected against any change in the properties of existing background groundwater. This option is not realistic though as other land uses compete with the water supply. Protection of groundwater must be of a preventative nature as clean up and rehabilitation are costly. The large scale utilization of the fractured bedrock also makes it difficult to establish capture zones. Cases are known where interference of pumping is felt kilometres away in one specific direction. There are areas which are particularly prone to contamination due to their short flow path to the aquifer. These areas include the areas of high recharge probability and shallow overburden aquifers.

Land uses that are considered a threat to the water supply include:

- "High density" sewage disposal (lot areas smaller than those recommended in this report)
- Domestic and industrial solid waste disposal
- Uncontrolled agricultural practices
- Industrial activity (eg. underground spills)
- Storage facilities for potential contaminants
- Transportation corridors (e.g. surface spills, road salting)
- Aggregate extraction activities (recharge interference, fuel spills, illegal dumping)

A recharge probability map has been created for planning purposes (Figure 14). Sufficient detail or local factual information is not available to assess if the potential pollution sources will be a threat to the water resources. Prevention and protection should come through scrutinization of the potential pollution sources. This may include a case by case assessment of the threat to the groundwater source by the potential polluter. This applies even in the areas of low recharge probability. Such an investigation should not only comment on the hydrogeology but should also identify the magnitude of threats. The benefit of such an approach is that it leaves the responsibility with the potential polluter and not the user.

6.5 Recommendations

In areas of development pressure, water budget studies are essential. Growth areas on private water supplies will only have a very limited effect on the regional supply in areas where relatively thick overburden is present. This however may not be the case for the areas situated in shallow overburden. Future work should include the evaluation of:

- flow mechanisms;
- long term yield studies;
- the nature of the connection between the main hydrogeological units;
- the degree of urbanization and its effect on recharge;
- the aquifer boundaries;
- the aquifer block flow time;

- hydrogeochemical patterns within each groundwater system;
- expected isotope signals for flowsystem and groundwater age evaluation;
- additional numerical modelling of densely developed areas.

In addition, the Ontario Government should consider the establishment of well head protection legislation as has been done in Europe and in the U.S.A..

Water quantity for private individual supply can be met in most cases by the regional aquifers in the study area. Only a few areas are known where the aquifers do not meet this demand. In many cases, additional storage can often provide the maximum peak demand. The performance of marginal aquifers needs to be more carefully evaluated from a cumulative impact view point.

Due to the susceptibility of the aquifer to contamination in recharge areas, development on private services should be discouraged in these areas. Furthermore we recommend that a "watch dog" monitoring system be developed for the above identified pollution sources to safeguard the groundwater resources. Municipalities should take leadership in monitoring these activities and their impacts on the groundwater. The application of Reasonable Use Criteria should be enforced on new developments. Developments belonging to this group should be allowed to proceed only on the presentation of a satisfactory impact review and a satisfactory contingency plan.

7.0 PRIVATE SEWAGE DISPOSAL

7.1 Background

A literature review was completed on the subject of private individual sewage disposal systems. Current conventional systems are designed as effluent disposal systems. These systems provide treatment of Biochemical Oxygen Demand (BOD) and bacteria, but provide very little removal of the nitrogen. The reduction of nitrogen is achieved by dilution. These conventional beds are acceptable for use to service very low density dwellings in rural areas. They are not designed to provide the required treatment for high density development.

7.1.1 Evidence of Septic System Failures

Local Health Units and the Ministry of the Environment were contacted to determine the extent of widespread contamination. Unfortunately, no compiled information was available from the government agencies, and exhaustive assessment and quantification of problem areas was not provided for in this study.

The available information was mostly generated through personal experience of some of the Directors of Part VIII of the Environmental Protection Act. The information provided identified the most common problems with septic systems:

1) Nitrate pollution
2) Bacteriological problems
3) Undocumented viral contamination
4) Hydraulic failure of a septic bed

The hydraulic failure is the most commonly detected problem by the Part VIII program. Other incomplete reports show occurrence of localized septic system nitrate contamination (Figure 6). In almost all the highlighted examples, this contamination mainly occurs where the surficial aquifer is utilized as the source of groundwater or where little overburden is present over the bedrock aquifer. Part VIII Directors indicated that no reports of wide spread enteric disease have been reported. Unlike nitrates, little is known about the migration behaviour of bacteria and viruses. In the United States, reports show extensive nitrate contamination in high density (i.e. lot sizes less than .2 ha) development in similar geological settings as those found in the study area.

7.2 Existing Guidelines

Table 4 compares U.S. EPA regulations with MOE's present Regulations and with the new MOE guidelines (February 1992). In general, U.S. guidelines are more stringent than present MOE guidelines. The U.S. Regulations require thicker minimum soil and allow for alternative treatment designs that have documented treatment performances (e.g. peat beds and aquarobics). The U.S. regulations also allow for designs that upgrade natural conditions in certain terrain to improve disposal operation (eg. lowering water table, importing fill material, etc..).

Presently the MOE is rewriting its Regulations for the construction of septic systems. It appears that the MOE's preference is municipally owned and operated communal systems to service future development. Consideration has been given to the following three options:

1) mandatory impact assessment of septic system effluent for each leaching bed using the Ontario Drinking Water Objectives.
2) mandatory impact assessment of septic system effluent for each leaching bed using the Reasonable Use Criteria.
3) no more approvals of conventional waste disposal systems.

7.3 Impact Assessment

Where servicing occurs by private individual septic systems, two limiting design criteria will dictate the impact on the environment. These two criteria include excessive hydraulic mounding in low permeability soils (eg. effluent breakout of the surface) and excessive nitrate loading in permeable soils (eg. downgradient groundwater contamination). Sustainable development should take the following three criteria into account:

1) The ability of the overburden to transmit the sewage effluent
2) The ability of any underlying materials to protect the aquifer
3) The ability of the hydrogeologic systems to ensure acceptable cumulative impact.

The ability of the overburden to transmit the effluent was simulated by the use of the numerical modelling code MODFLOW. The response of the overburden to nitrate loading was simulated by the use of the numerical modelling code (MOC). MODFLOW and MOC are well documented simulation methodologies. Their applications are widespread in the hydrogeological community (Appendix D, Parts I and II).

7.3.1 Soil Thickness

Following the present practice in the Northeastern United States, a mineral unsaturated soil thickness of 1.2 m is recommended as a minimum thickness below the sewage tiles (Defeo and Wait 1990). Natural soil of at least 0.3 m in thickness should be upgraded with the importation of suitable material to complement the natural soil, bringing it to a minimum of 1.2 m in total soil thickness. This recommendation will permit sufficient aerobic condition below the bed to reduce the BODs (Biochemical Oxygen Demand) and bacteria. No development should take place if natural mineral soil thickness is less than 0.3 m over the bedrock in the leaching bed and mantle areas.

As a word of caution, any importation of fill to be placed over fine grained soils should be completed with great care in order to avoid smearing and "sealing" of the surface. The bed area should be located and fenced off before construction. Top soil should be stripped with light weight machinery. The new surface should be plowed or rototilled.

In the study area, typical terrains consist of thick clays, thick tills, thick sands used as aquifers, thin sands overlying clays and thin sands overlying bedrock. Mounding computation and flowthrough assessments of nitrate loading should be completed on all terrain to determine which parameter is the limiting design criterion. This determination needs to be made as early in the development process as possible.

7.3.2 Mounding Criteria

Computer simulations with MODFLOW under spring time, worst case scenario (i.e. groundwater tables at the ground surface), have shown that most conventional septic systems will fail hydraulically, that is break out on the ground surfaces when constructed in medium to fine grained soils (Appendix D-I). Up to 1 m of mounding is generated in clay soils. This mound is double the allowed mound in a typical fully raised bed. Septic system leaching bed design should be altered by increasing the vertical separation distance from 0.9 to 1.2 m below the leaching tiles to allow for aerobic conditions. Alternatively, a leaching bed could be enlarged to reduce the loading rate and the associated maximum mound to the allowed 0.4 m, leaving .5 m of unsaturated soil below the tile. This reduction of the mound will require a greater area in order to impede excessive hydraulic mounding. In either case, major lot upgrading is required in order to make it suitable to absorb septic system effluent (Appendix D-I).

7.3.3 Nitrate Loading Criteria

Domestic sewage released into the subsurface has the potential to contain a variety of contaminants. The persistence of nitrate in groundwater makes it the critical contaminant. Nitrates have therefore been utilized in the evaluation of septic system impact. Some septic tank cleaners contain organic solvents (eg. T.C.E.) which can contribute toxic compounds into the groundwater.

Cherry (1990) documented that in permeable soil, (e.g. Cambridge and Muskoka), nitrate concentrations from septic systems form a long and narrow plume. His measurements/simulations have shown that a nitrate plume would be dispersed to a concentration of 10 mg/L at a distance of 130 m from the source. The plume would be in excess of the "reasonable use criteria" of one fourth the drinking water limit (2.5 mg/L) for Nitrate at a distance up to 2 km. The Reasonable Use Criteria is based on a maximum concentration of a particular contaminant that would be acceptable in groundwater beneath the adjacent property as outlined in Ministry of the Environment Policy 15-08. These findings suggest that in areas where upper sand formations are utilized as both aquifers and effluent disposal, safe lot sizes for sustainable use of the aquifer would require a length of 2 km in the downgradient direction if the reasonable use concept is applied.

Two methods of assessing the nitrate impact are presently recognized, namely the Infiltration Method (Bucket approach) and the Flowthrough method. Using the Infiltration Approach, as outlined in the generic guideline of the Province (Central Region's Appendix C) lot sizes would vary as follows:

SOIL TYPE	LOT SIZE TO MEET 10 mg/L NITRATE (ha)
Dense Clay	2.9
Clayey Silt	1.5
Silt	1.2
Sandy Silt	1.0
Medium Sand	0.7
Gravel	0.6

This method clearly indicates a trend towards smaller lots on more permeable soils. The rational is the greater availability of diluting water. The limitation of this approach lies in its basic assumption of complete mixing of the effluent with the infiltrated water. This method was developed as a planning assessment but clearly cannot be defended on a technical basis (Figure 16). (Personal Communications by Clyde Hammond, Jim de Cruz, Bill Blackport, 1991).

Flowthrough simulation was completed in coarse sandy soils (Cherry 1991) and indicated that the lot size would be 1 ha in sandy soil with a hydraulic conductivity of 10^{-2} cm/sec. in order to meet the drinking water limit of 10 mg/L NO_3-N and 12 ha to meet the Reasonable Use Criteria of 2.5 mg/L. Flowthrough simulation was completed by Geo-analysis Inc. with the use of the numerical model MOC.

In order to meet the Reasonable Use Criteria of 2.5 mg/L on common Eastern Ontario sands ($K = 10^{-3}$ cm/sec), lot sizes are 1.7 ha for 10 m thick saturated sand, under a typical gradient and assuming no denitrification. In material with a conductivity less than 10^{-4} cm/sec (siltier materials), little plume migration would develop under a typical gradient. The limiting design criteria in silts and clays is the excessive mounding.

7.4 Lot Size Determination

Considering that the State of New Hampshire has a minimum lot size of 2.0 ha for private services, and that the West Central MOE Region is doing similar impact assessment yielding large lot sizes in thick permeable soils and that the Southeastern MOE Region has recently adopted 1 ha typical lot size in the February 1992 MOE workshop in Kingston. It appears that the lot size determination derived in the present study is corroborated (Personal Communications, Clyde Hammond, Jim de Cruz, Bill Blackport, 1991).

7.5 Recommendations

Table 5 summarizes the recommendations as a flow chart process. It is recommend that, in this study area, 1.2 m of mineral unsaturated soil be present in the leaching bed area. When low hydraulic conductivity soil is present, lot size should be determined by mounding calculations. This will typically result in lots of 1.5 to 2.1 ha in size. Caution should be given to fractures and fissures in the clays, particularly in thin deposits. The bulk hydraulic conductivity may behave more like a granular material in which case plume delineation should be determined.

When the overlying material has at least 10^{-3} cm/sec. hydraulic conductivity and is a potential aquifer, the flowthrough method should be completed. Typical lot size will be 1.7 ha where underlying material is 10 m of saturated sand and 2.5 mg/l is the nitrate criterion.

When the overlying coarse grained soil has no potential for aquifer use and the bedrock is the main aquifer, the underlying stratigraphic unit should be verified. If the sand or permeable material is underlain by at least 1.2 m of native clay soils with no fracturing and low hydraulic conductivity, mounding assessment should be completed. A typical lot size will be 1.5 ha. If the sand or permeable material is underlain by less than 1.2 m of clay type soils and is mainly underlain by bedrock, a flowthrough assessment in the bedrock aquifer should be completed. Typical lot size will be greater than 2.2 ha. Selected hydraulic conductivity values should be based on field measurements. The use of the Guelph Permeameter is strongly recommended to standardize the in-situ values.

It is recognized that the level of confidence of flowthrough assessment in bedrock aquifers is low. The high velocities and the reduced attenuation in fracture flows only suggest very large lots. In-situ conditions should be evaluated and lot size determined by the 2.5 mg/L nitrate plume outline.

From the surficial geology map and the overburden thickness map, the aquifer management system generated a terrain suitability for septic systems map (Appendix H). The protection of the aquifer as a potable groundwater resource is the main focus underlying the terrain suitability map (Figure 17). The best areas basically consist of thick, low hydraulic conductivity soils which offer a natural safeguard to the protection of any underlying aquifers. In places, the thick clay will be overlain by higher hydraulic conductivity soils which do not have an aquifer potential. In these terrain conditions, where the underlying aquifer is good, the lot size will be approximately 1.0 ha based on mounding calculations.

Furthermore, where seasonal high water tables are below ground surface, mounding calculations would suggest smaller lot sizes.

7.5.1 Common Sense Hydrogeology

The above lot size determinations are based on our best knowledge of how natural systems may respond to effluent loading from leaching beds. All input parameters were evaluated to represent our best assessment of reality. Modelled nitrate loading outputs represent worst case scenarios since it is assumed that no denitrification will occur in the soil. Even if denitrification can be documented in the short term, buffering capability may be used up over time. Proposed lot sizes are scientifically defendable.

However any proposed development on private individual services on specific terrain conditions may differ from these recommendations. It is recommended that development on marginal terrain be phased in order to observe actual results before allowing subsequent phases of the developments (say 20 lots or 50% of the subdivision). The location of services should be based on field evidence of shallow groundwater flow characteristics. It is understood that, in certain circumstances, the 2 year monitoring period could be replaced adequately by the monitoring of existing nearby septic systems.

The nitrate plume should be simulated based on site specific conditions, and should be monitored for 2 years following the continuous use of the sewage system. The extent of the 2 year plume of 2.5 mg/L NO_3-N should be compared with the site specific simulated outline in order to assess for any denitrification processes. If the aquifer systems perform better than predicted at that location (eg. because of elevated organic contents (f.o.c.)), the density of the development could be altered from the present recommendations. Caution should be exercised in assuming that the denitrification process will continue indefinitely.

The MOE South Eastern Region has adopted guidelines that require an impact assessment for lot sizes less than 1 ha on areas that have not been designated by the Part VIII Director. These guidelines require that the impact assessment demonstrates that 10 mg/l Nitrate is met at the property boundary. In the impact assessment denitrification and other nitrate reducing processes are taken into account. The Ministry position assumes that nitrate reducing processes will likely reduce nitrate to less than 2.5 mg/l.

7.5.2 Alternative Technologies

Alternative technologies are being developed to treat septic system effluent. These systems provide a level of treatment of septic system effluent and require less area to reduce loading of the systems to background levels. As these alternative technologies become accepted by the Ontario regulatory agencies, lot sizes could be reduced, as less area is required for dilution.

A non-exhaustive listing of alternative treatment systems include the following:

a) Aquarobics - A mini nitrification-denitrification plant, where the end result is treated effluent to near background levels. Presently, the plants are expensive (in excess of $10,000) and require substantial maintenance, and as such they are not ready for widespread applications.

b) Class 6 system - Several units are available that reduce the BOD of the effluent. Nitrate treatment is not provided however and the question of dilution still remains.

c) Peat Beds - A specific grade of peat is used to provide treatment of effluent. The system is successful in reducing nitrate to within Reasonable Use levels. Costs are similar to conventional systems and the source materials are abundant in Southeastern Ontario. The State of Maine has accepted this system for sewage disposal and treatment. Some pilot projects are underway in Ontario. Peat beds appear to offer the greatest potential for treatment. This may imply that, once accepted, lot size requirements on permeable soil may be reduced significantly from the sizes proposed in this document.

Until new technologies are approved in Ontario, conventional septic systems developed on permeable soils will generate plumes, and large lots will be required. Interim options to large, individually serviced lots may include the following:

a) Moratorium on privately serviced development.
b) Communal systems - A cluster of residents could be hooked up to a central treatment plant (MOE would currently require that the municipality maintain or be ultimately responsible for it)
c) Holding tanks - The municipality contracts with a hauler and the pumped sewage is hauled to a sewage treatment plant or lagoon maintained by the Municipality (this assumes that reserve capacity is available at nearby sewage treatment plants and that the municipality is willing to accept it).
d) Greater emphasis is placed on fully serviced planned development.

8.0 CUMULATIVE IMPACT AND DISTRIBUTION OF RURAL DEVELOPMENT

8.1 Cumulative Impact

Three years ago, a 0.2 ha lot size was common for many rural developments especially hamlets. As previous sections have shown, large lot sizes are desired to minimize potential negative impact from septic systems on the groundwater supply. Since 1988, when the Reasonable Use Criteria was adopted, (but no area designated for subdivision approval), impact assessment has been required by MOE Southeast Regional hydrogeologists on a case by case basis. The sustainability of development was usually not considered with regards to cumulative effect of neighbouring subdivisions.

On the groundwater supply aspect, a review of in excess of 200 subdivision reports in the study area has shown that long term groundwater demand and interference are usually assessed by questionable methodology. Main weak areas for the assessment of groundwater supply include:

a) Pump tests are performed for too short a duration to determine aquifer boundary conditions.

b) Pump tests are not performed at aquifer capacity; therefore, theoretical estimates of aquifer parameters are unreliable.

c) Water quality changes due to development are not addressed.

d) Raw water quality is not compared with existing adjacent property wells.

The aquifer management system has outlined most and least suitable areas based on water supply viability and conventional septic system development (Figure 18/Appendix I). Nevertheless, the need to complete a hydrogeological assessment for each individual development remains essential. The effects on existing and future development should typically address two main areas, namely impacts created due to the exploitation of the groundwater resources and those due to contamination caused by the operation of septic systems.

8.2 Distribution of Rural Development

An aquifer management system was developed for the study area (Appendix I). It has outlined where sustainable development on private individual services can be encouraged. It has identified a method of calculating how much sustainable development can take place on a particular site. Development on private individual services should be discouraged in areas where natural continuous soil thicknesses are less than 1.2 m. Development on private individual services should not be allowed in where natural continuous soil thicknesses are less than 0.3 m. Until alternate technologies are approved by the Regulators, sustainable development on permeable soils will demand large lots, particularly where the upper formation has potential to be used as an aquifer. The best terrain for development consists of thick fine grained soil where the bedrock is the regional aquifer.

8.3 Recommendations

Ideally the minimum requirements to assess cumulative impact should address the following:

I) For Water Supply:

a) Aquifer boundary conditions
b) Aquifer long term sources
    i.e. - Leakage from upper aquifers
    - Surface waters
    - Infiltration
c) Changes in water quality due to pumping by exhaustive survey of existing nearby wells
d) Effects on existing users
e) Calculations and methodology to address hydraulic impacts

II) For Septic Systems:

a) Nitrate loading to the shallow groundwater and aquifer and surface water on and off site
b) Other contaminant loading to the shallow groundwater and surface water (if applicable)
c) Determine flow paths of contaminants prior to development and after development
d) Mounding calculations
e) Determine the appropriate lot size based on the detailed study

In order to be able to assess changes due to development, sampling stations should be set up in undeveloped areas and developed areas. Cost of these monitoring stations should be borne by the developer. Upon acceptance of the subdivision, ownership of these wells should be transferred to the municipality. These locations should be monitored for changes in base level of the aquifer and in the quality of the water supply.

Presently, the RMOC has a guideline of 40 lots at a time per subdivision applications. It may be desirable to review the impact of development on a 20 lot phasing, and of one development on other developments. This phasing should take into account the site's hydrogeologic conditions in the lot layout. Contiguous developments should not take place until the performance of the wells and septic systems from the existing nearby development has been assessed.

In order to ensure the integration of cumulative impact considerations in the creation of future lots with sustainable individual private services in the rural area, the Reasonable Use

Criteria should apply for the creation of new lots sized with the flowthrough method (i.e. 2.5 mg/L nitrate), where the overburden is used as an aquifer. It also means that no significant hydraulic head generated by the septic system mounding would permit a flow of effluent onto neighbouring land. Development density limitation is the only control that will allow the cumulative impact to be acceptable.

New development adjacent to an existing subdivision should only be permitted it if meets the following criteria:

a) The existing phased subdivision should be sufficiently developed to demonstrate its ability to function on a sustainable basis.

b) Groundwater quantity and quality at the earlier phase of the subdivision are performing as expected.

c) Monitored mounding and nitrate loading are better than simulated.

Also, documentation of the aquifer behaviour should be initiated for long term monitoring. This could typically include the installation of wells in the several available aquifers in strategic locations. These wells should be provided by developers and ownership transferred to the municipality which will manage a network of monitoring points. Furthermore, these stations could be monitored to document water quality changes with aquifer use. Further study should be undertaken to address the following issues:

- Detailed documentation of aquifer flow
- Determination of effects on flow patterns with increased urbanization
- Determination of water quality changes brought about by developments
- Determination of long term groundwater level changes as a result of development
- Determination of guidelines for groundwater heat pumps
- Determination of aquifer replenishment cycles
- Creation of long term aquifer gauging stations.

9.0 RURAL DEVELOPMENT POLICIES

9.1 Statement of the Problem

Groundwater serves a significant portion of the study area population. With the exception of the central water supply system serving the urban area of Ottawa-Carleton, very little of the population is dependent upon surface water for domestic water supply purposes. The Town of Arnprior uses water from the Madawaska River, the Town of Rockland uses Ottawa River water and the Town of Carleton Place uses water from the Mississippi River. Although the Town of Smiths Falls, just outside of the study area, uses surface water from the Rideau River, no other municipalities use this source.

All of the remaining rural area and the Towns, Villages and Hamlets, such as Braeside, Pakenham, Almonte, Kemptville, Merrickville, Richmond, Manotick, Metcalfe, Chesterville, Winchester, Embrun and Russell are dependent upon groundwater, either through the individual wells or communal wells with piped water distribution systems. Approximately 18% of the 1988 study area population of 706,000 (including urban area) is dependent on groundwater. This represents approximately 127,000 people.

A review of existing developed and undeveloped lots (from 1990 assessment sources) suggests there are approximately 35,400 developed lots with an additional 18,800 vacant lots potentially available for development in the more rural portion of the study area (excluding Gloucester, Nepean, Cumberland, Kanata and Goulbourn).

Groundwater use in Canada is growing, having doubled between 1966 and 1985. As further growth occurs and competing pressures for rural land uses also grow, the potential for groundwater problems increases.

A survey of 560 wells in the Regional Municipality of Waterloo indicated that 68% of the dug wells and 22% of the drilled wells had bacterial contamination with 29% of the dug wells and 3% of drilled wells exhibiting nitrate levels in excess of 10 mg/L. Similar results have been encountered within a portion of the study area. The Leeds, Grenville and Lanark District Health Unit reported that 19.4% of 6,115 samples taken in 1990 were "bacteriologically unsafe for drinking water purposes due to the presence of fecal coliform organisms." The same agency reported that 14.2% of 712 samples had nitrate levels in excess of 5 mg/L with 4.1% of those exceeding the Provincial drinking water objective of 10 mg/L. Figure 6 identifies the locations of some localized water quality and quantity problems within the study area.

The following list of potential contamination sources, adapted by Environment Canada from material by John A. Cherry, provides an indication of the types of activities which may negatively impact upon groundwater:

Point Sources:

On-site septic systems
Leaky tanks or pipelines containing petroleum products
Leaks or spills of industrial chemicals at manufacturing facilities
Underground injection wells (industrial waste)
Municipal landfills
Livestock wastes
Leaky sewer lines
Chemicals used at wood preservation facilities
Mill tailings in mining areas
Fly ash from coal-fired power plants
Sludge disposal areas at petroleum refineries
Land spreading of sewage or sewage sludge
Graveyards
Road salt storage areas
Wells for disposal of liquid wastes
Runoff of salt and other chemicals from roads and highways
Spills related to highway or railway accidents
Coal tar at old coal gasification sites
Asphalt production and equipment cleaning sites

Non-point (distributed) Sources:

Fertilizers on agricultural land
Pesticides on agricultural land and forests
Contaminants in rain, snow, and dry atmospheric fallout

Most of these potential sources are found within the study area.

A fundamental concern in groundwater management is the long time it may take contaminants to show up and the equally long time it takes to correct problems. In light of the high cost of correction, prevention becomes the most prudent means for dealing with potential groundwater contamination problems. Experts lament the fact that there is generally more expertise available to deal with cures than there is to deal with prevention. Similarly, funds are available to establish an emergency water supply but not for communal systems to serve planned development of new villages and hamlets.

9.2 What Is Being Done Now That Affects The Study Area?

(a) Groundwater resource protection is in its infancy in the study area and, to a lesser extent, in Ontario. From a Provincial perspective, numerous steps are beginning.

The Ontario Ministry of the Environment, recognizing that private sewage disposal system standards developed 20 years ago are no longer adequate, introduced a draft Policy To Govern The Assessment Of Rural Development

To Be Serviced By On-Site Sewage Disposal Systems for discussion purposes among the Ministry offices and Health Units in March, 1989. It suggested a minimum lot area of 1 hectare and a requirement for an alternate tile bed on any proposed lot, among other requirements. In February 1992, this policy was reconfirmed in an altered form, stating that no impact assessment is required if proposed lots exceed one hectare.

The Ministry of the Environment is also said to be working on a new Safe Drinking Water Act which could be ready for introduction at any time.

The Ministry of Natural Resources is developing an Ontario Water Conservation Strategy to help reduce water consumption.

The Ministry of Agriculture and Food is encouraging improved environmental practices in agriculture through such programs as Land Stewardship II and Food Systems 2002.

The Ontario Soil and Crop Improvement Association conducted a broad well sampling program (1340 wells) covering all of Southern Ontario. It is attempting to determine the quality and safety of drinking water for farm families as well as determining agricultural impacts on groundwater. Although the sampling has been completed, the final report will not be released until the summer of 1992.

The Joint Federal/Provincial Royal Commission on the Future of the Toronto Waterfront, which has made a number of generic recommendations through its Watershed report, has expressed concern about groundwater impacts and the need for care to be taken in the preservation of this resource.

The Ontario Environmental Assessment Advisory Committee, in Report #38, made a number of specific recommendations on the Ganaraska Watershed with the first part of Recommendation #1, addressing groundwater. The report went on to make a number of generic recommendations regarding long term needs for environmental assessment and stewardship of groundwater resources.

Although some discussion occurred over the past year about a "greening of the Planning Act", no action is now expected until the Commission on Planning and Development Reform in Ontario (Sewell) has reported in June 1993. One goal of the Commission is to link environmental issues such as groundwater protection with land use planning. One of the Commission's newsletters (1991) described some areas where significant groundwater contamination had occurred and referred to the septic system failure issue as a "sleeping giant". The second draft of the Planning Goals (April 1992) indicates a softening of the Commission's initial position of an outright ban on septic systems, now stating that their use would be discouraged and "not permitted in new multiple-lot developments.

The Ministry of Consumer and Commercial Relations has been advising interested parties over the past year that 'environmental warnings' are not acceptable for registration on title unless they form part of certain types of agreements, including those for consents and subdivisions, limiting this avenue as a means of cautioning people about potential groundwater problems.

These numerous, interrelated activities will undoubtedly have some impact on the groundwater preservation/rural land use issues over the next short period of time.

(b) The Rideau Valley Conservation Authority is in the process of preparing a Conservation Strategy. The February 1991 watershed strategy mentions groundwater quality and quantity as a resource issue which could be addressed. The Conservation Authority Act grants power to: "study and investigate the watershed and to determine a program whereby the natural resources of the watershed may be conserved, restored, developed and managed."

(c) The Board of Health of the Leeds, Grenville and Lanark District Health Unit has been considering a policy which is somewhat similar to the draft Ministry of the Environment Policy. It suggested that the municipalities require a minimum lot area of 1 ha. (2.5 acres) and a minimum lot frontage of 75 m (250 ft.). A reserve area for an alternate leaching bed would be required and a separation distance between any sewage disposal system and a well would be a minimum of 30 m. Applicants who wish to have a reduced lot area considered would be required to conduct a Reasonable Use study under Ministry of the Environment Policy 15-08. It was noted that of 9,259 sewage systems approved from 1985 to 1990, 3.5% were for undersized lots or lots without adequate suitable land area.

(d) The Official Plan of the Regional Municipality of Ottawa-Carleton includes an objective of ensuring that rural development "does not threaten the quality or quantity of ground and surface water" (Section 4.1, Policy #3) and (Section 10.1.1, Policy #4). The policies that flow out of these objectives include:

- A requirement for detailed hydrogeology investigations to support Village expansions. It is significant to note that the development of existing Villages does not have to first have hydrogeological justification.
- Country lots must generally have a minimum lot area of 0.8 ha.
- Individual subdivisions or phases are limited to 40 lots, but no monitoring period, before additional phases can be considered, is required.
- Groundwater quality is expected to meet or exceed the Ontario Drinking Water Objectives, although it is not specified whether treatment is permitted first. Regionally controlled communal servicing systems can be considered for some multiple development, under specified conditions, but are not an acceptable alternative for other forms of rural residential development.
- Rural plans of subdivision, prior to draft approval, must be demonstrated to have a "natural supply of water of sufficient quality and quantity to support

the proposed development without adversely affecting the quality or quantity of water in other wells operating in the general area" but there is no requirement to protect supplies for potential future wells.

- Prior to subdivision draft approval, it must be demonstrated that the site can support the safe operation of private sewage disposal systems but the policy does not require a demonstration that those systems will not negatively impact upon downgradient water quality, for example. The same policy and the same limitation applies to new lots created by consents.
- A lot created by consent must be demonstrated to have a natural supply of water of sufficient quality and quantity to support the development but cumulative impacts of consents are not addressed.
- Regional Official Plan amendment #21 was approved on February 15, 1992, incorporating a requirement for the local Official Plan policies to protect the groundwater resource serving the Village of Carp. Other areas of the RMOC are not yet required to do this.

(e) The Official Plans of the area municipalities within the Region and the Official Plans of the Townships outside of the Region are all virtually silent on the issue of cumulative impact of rural residential development. Some policies are found which require an adequate quantity of well water (but are seldom enforced) but most simply defer private servicing issues to the Ministry of the Environment and/or its agents. Official Plan policies and Zoning regulations allow a variety of minimum lot sizes ranging from 0.2 ha. (0.5 acre), and sometimes slightly smaller for infilling lots in hamlets, to the frequently encountered requirement of .4 ha. (1 acre) and estate lot sizes of 0.8 ha. (2 acres), 4 ha. (10 acres) and sometimes 10 ha. (25 acres), and ranges in between.

(f) Water well construction standards are established under Ontario Regulation 612/84 under the Ontario Water Resources Act but Ministry of the Environment staff constraints result in virtually no proactive field inspections by that agency. As a result, 6 municipalities in the study area have undertaken Well Compliance Programs. Correspondence between the Ministry of the Environment and one of the municipalities located in the study area, indicates the need for municipal staff undertaking this responsibility to be designated as Provincial Offences Officers under the Ontario Water Resources Act.

(g) The Ministry of the Environment Well Logs were placed on electronic file up until 1985. Due to staff constraints, well logs since that time have not been compiled and were therefore not available for inclusion in this study. Dug wells and sandpoint wells are similarly not recorded.

9.3 What Is Being Done Elsewhere?

(a) European and U.S. experience is considerably greater in the field of groundwater protection. Well head protection provisions, for example, have been included in some European jurisdictions since the 1950s and were incorporated into the U.S. Safe Drinking Water Act in 1986. It should be noted, however, that many of those provisions only apply to communal wells.

The discovery of vast groundwater contamination problems in the United States has resulted in extensive research and policy formulation to deal effectively with groundwater issues. Surveys have suggested 3 broad approaches which are used by various States (Jaffe and DiNovo, American Planning Association, Local Groundwater Protection, 1987).

i) Non-degradation, where maintenance of existing groundwater quality at its existing level is required (16 states using this approach).
ii) Limited degradation, where specific water quality standards are set, allowing some quality declines (17 states).
iii) Differential protection, where different protection standards are set for different parts of the state, based on aquifer characteristics, use, vulnerability, etc. (12 states).

Numerous variations occur. An example quoted was Wisconsin, where nitrate levels of 10 milligrams/litre are adopted as "enforcement standards" but levels of 2 milligrams/litre are established as "preventive action standards" requiring steps to begin to be taken. The U.S. experience indicates a broad array of federal, state and local controls over groundwater contamination sources.

Among the contaminant sources controlled by local government, are agricultural chemicals, animal confinement feeding, agricultural irrigation, sewer systems, solid waste disposal, hazardous waste disposal, underground storage tanks, underground injection of waste, oil and gas production, aquifer penetration such as major excavations, groundwater development projects and, very importantly, on-site sewage disposal systems. Jaffe and DiNovo suggest that:

> "Of all the known sources to contribute to groundwater pollution, septic tank systems and cesspools directly discharge the largest volume of wastewater into the subsurface." Pg 112

Similar to some of the conclusions now being reached in Ontario, they also suggest that the major concern used to be sewage system clogging and hydraulic failure, such as ponding or breakout:

> "The potential impact of these systems on groundwater was little regarded, beyond making certain that sufficient separation existed between them and nearby wells to eliminate bacterial pathogens. Highly permeable soils are now regarded by environmental health officials as unsuitable for the treatment of sanitary waste." Pg 112

Typical problems identified were nitrates, pathogens and organic chemicals from the use of septic tank additives and household chemicals.

Prevention is stressed as the most effective way to deal with potential contamination. The design of systems which deal with specific site constraints was suggested.

> "These systems include alternate dose systems, multiple drain field systems, mound systems, package aerobic treatment systems or waterless toilets. Technical innovations, including systems that use additional leaching beds to convert nitrate to gaseous nitrogen (denitrification) are being developed but are not yet commercially available." Pg 114

A pilot study in Michigan identified a number of problems with sewage systems.

- Improper siting practices;
- Cumulative effects of septic systems in new subdivisions
- Overly liberal granting of variances for septic system permits
- Residential infilling of lakefront areas
- Improper septic system use and maintenance;
- Unsafe septage disposal" Pg 115

It is interesting to note that the specific lot size conclusions reached in a number of U.S. jurisdictions are in the 1 to 2 acre range while in some instances they rise to 5 acres, 35 acres and 40 acres. These conclusions are not particularly relevant to the study area but serve to point out the range of conclusions which can be reached when a well researched program is developed for a specific area.

(b) The Province of Prince Edward Island is virtually entirely dependent upon groundwater for domestic use. In 1990, a Royal Commission (Boylan Commission) reported on a wide range of development issues. The Spring 1991 throne speech of the government indicated its intention to act on the Royal Commission findings. A follow-up document, dated July 1991, entitled "Land Use and Development in Prince Edward Island: Issues, Choices and Policy" stressed a number of issues including the importance of groundwater quality.

In order to ensure sustainable development, a number of objectives and principles were stressed, including sound natural environmental management principles, efficient use of the land and services which precede rather than follow development. One of the main factors quoted in deciding to implement the Royal Commission Report:

> "...is that the development course which is currently being followed is one which is more costly than it need be. For example, the principle that services can follow, rather than lead development, has already resulted in having to expend large sums of tax dollars in repairing environmental damage." Pg 5

(c) In Ontario, in addition to the Provincial initiatives previously described, a number of Regional Municipalities are now becoming much more conscious of groundwater contamination problems and are undertaking studies of the issue. One of the leaders is the Regional Municipality of Waterloo, not surprisingly, since it is fully dependent upon groundwater supplies to serve a population of 350,000 people. Extreme contamination problems associated with the Uniroyal Plant in Elmira have served to focus attention on the potential costs of not taking proper precautions.

The specific problems encountered in Waterloo have also focused on the need for municipal action if groundwater protection is to be achieved. The Regional Municipality of Waterloo has realized that it may end up paying the price for inaction and concluded that it is an appropriate municipal planning response to take direct control over its own groundwater destiny.

In 1991, the Region of Waterloo staffed its own Hydrogeology Department and developed a document entitled, "Guidelines for Hydrogeological Studies for Privately Serviced Developments", dated May 1991 (Appendix J). This document is particularly interesting for two reasons:

i) It establishes a two stage evaluation process; a preliminary step which establishes an overview of a site's capability and permits an applicant/developer to bring his proposal part way forward, with only part of the expense, followed by stage two, a study which produces more detailed information to justify final approval.

ii) The Region of Waterloo specifically states a policy of preferring the establishment of communal water supply systems. The use of individual wells is discouraged. Staff indicate that this policy is based on the conclusion that a few properly located and constructed wells, under Regional ownership, is a preferable way to develop a groundwater source, permit monitoring and allow for communal treatment, where required. This approach is the opposite of the one used in the study area, where many municipalities have been reluctant to assume ownership/responsibility in rural areas.

A potential deficiency of the Guideline is its exemption of developments having 5 lots or less. If abused, numerous 5 lot developments could result in significant cumulative effects. Staff have indicated that, at least on one occasion, the optional approach of applying the study requirements to smaller developments has been imposed.

It is interesting that the new Region of Waterloo Hydrogeology Department, in spite of an interest in addressing rural development issues, has been preoccupied with major concerns of long term overall water protection programs, well head protection and industrial contamination.

9.4 Conclusions

(a) Comprehensive groundwater protection planning is only beginning in Ontario, when compared to European and U.S. examples. The present study area is not a leader but is beginning to take more action than many other parts of the Province. Much remains to be done. Although massive work has been undertaken in the U.S., it was in response to massive problems. The level of effort required in the study area is proportionally less.

(b) The groundwater implications of rural development are the concerns of both provincial and local government. Jurisdictions overlap and problems are not always addressed. This is not significantly different from the U.S. experience. Policies and programs can be developed to address the issues in spite of these constraints.

(c) The Official Plan policies of the study area municipalities do not clearly state the long term goals for groundwater protection and back them up with clear implementation strategies. The Official Plan of the Regional Municipality of Ottawa-Carleton goes the furthest towards this end but retains significant gaps.

(d) Prevention of groundwater problems is much cheaper than cure and this will become a greater and greater concern as senior government cutbacks are felt at the local level.

(e) The Provincial Ministry of the Environment is overloaded and will probably never be able to deal effectively with all the groundwater issues in Ontario's municipalities. Regulation of activities which impact upon groundwater is already fragmented and incomplete. No agency broadly assesses, plans, monitors and comprehensively deals with groundwater. Inside the Region, the Ministry of the Environment contracts out septic system approvals to private consulting firms. In the balance of the study area, the Health Units handle this responsibility. In most of the study area, no well construction supervision occurs except for test wells in subdivisions supervised by the applicant's hydrogeologist.

(f) The Ministry of the Environment's policy (requiring 1 ha. lots) is not technically defensible since it does not address nitrate plumes and groundwater flow direction issues. Instead, it emphasizes a greater dilution objective in the hope that at least massive problems will not occur. The real issue is the need for better private sewage treatment rather than more dispersed sewage disposal (dilution).

(g) The other chapters of this report have drawn conclusions and offered recommendations on how water quality and quantity, well construction, sewage system installation, aquifer recharge and cumulative impacts can be addressed. The aggregate conclusion, based on these factors, is an obvious need for more comprehensive hydrogeological investigation to support specific development proposals, combined with a significant increase in lot sizes, if sustainable development (using current technology) is to be accommodated in the rural areas.

(h) The GIS modelling results identified both conflicts and consistencies with existing planning approaches for rural areas. Figure 18 shows a major conflict between potential development and agricultural land preservation because good agricultural soils are also best suited for development. Of lesser significance are the conflicts between aggregate extraction and groundwater quality/quantity preservation due to interference with water tables, storage of fuels, etc. Even the potential extraction of peat for peat beds (presuming these are approved as alternative sewage treatment systems) conflicts with wetland preservation.

On the other hand, consistency is also found. Figure 18 also shows that areas like the thin soils of the Carp Hills, designated Marginal Resource Area (Restricted) in the Regional Official Plan, have low capability for development on private services. Similarly, wetland areas have low potential for development and often form an important part of the groundwater recharge system. The effective incorporation of hydrogeological concerns into the rural planning process will require earlier consideration of these elements in conjunction with these other policy issues.

9.5 Lot Size Implications of Computer Simulations

The results of the computer simulations described in Section 7 have significant implications for lot sizes and the planning of the resultant development. It is important that these results be put in perspective.

The results of mounding simulations for clay soils suggest the need for considerably larger lot areas if an adequate unsaturated layer is to be retained above high water tables and below the bottom of the leaching bed tiles to achieve adequate aerobic treatment before mixing with the groundwater. Appendix D, Figures D-I-2 to D-I-10 inclusive, identify a number of different terrain conditions and the resulting land area required to diffuse the effluent in the particular groundwater mounding condition encountered. Scenario C (Figures D-I-7, D-I-8 and D-I-9) describes the results for clayey conditions, demonstrating that tile bed/diffusion areas in the order of 1.6 ha to 1.8 ha would be necessary. These conditions are typically found in the study area. Using these results, Figure 19 has been prepared to demonstrate the development pattern which could result. Very large (1.7 hectares), almost square lots, would result in extremely large lot frontages with significantly increased road construction costs for developers and corresponding high maintenance costs for municipalities. The computer simulation assumes a 3,000 litres per day luxury dwelling, as required by MOE. If smaller dwellings with lower water comsumption habits can be assured, the resulting lot sizes could be reduced. As previously noted in Appendix D, worst case conditions such as spring high water tables have been assumed.

In permeable soils, a similar lot area results but with a radically different shape. Figure 20 demonstrates the design problem which results from the application of nitrate plume modelling. It has been generated using the results displayed on Figure D-II-3. A plume generated on 10 m of sand occupies an area of 1.6 ha using 2.5 mg/l as the nitrate criterion. Allowing additional land for the building, well and septic tanks, a lot area of 1.7 ha results. While frontages are narrower, the road must be placed perpendicular to the groundwater flow direction and if well water is to be protected, upgradient lands will need to be free of nitrate plumes. This could result in development on only one side of the road, making overall road constructions costs similar to the design displayed on Figure 19.

The overall development scenario displayed in Figure 20 assumes that current technology will continue to be used in the design and installation of private sewage disposal systems. If new systems are developed which treat nitrate or greater denitrification is proven to be occurring in the soils, it may be possible to redivide lots. As previously noted, the 1.7 ha lot area relates to a nitrate concentration of 2.5 mg/l. If 10.0 mg/l was used, the smaller plume results in a lot area of 1.1 ha, as shown in Figure 20. Current MOE policy suggests that denitrification processes will provide the needed reduction from 10.0 mg/l to the 2.5 mg/l level implicit in the "Reasonable Use" criteria. However, the resulting lot area of 40 m x 270 m would require careful orientation to groundwater flow direction.

While the large lot sizes which result from these calculations may make traditional rural residential and estate residential development more difficult and perhaps economically marginal, they virtually eliminate the traditional concept of concentrated Hamlet development on privately serviced 0.2 ha. (0.5 acre) lots.

Rural planning, in the past decade, has often evolved into the preparation of a map identifying agricultural lands, mineral aggregate resource areas, flood plains, wetlands, ANSI's (Areas of Natural and Scientific Interest) and other constraint areas and restricting development on them. The implementation of this study's conclusions would serve to severely restrict the development potential on the remaining "Marginal" lands as well. Individual provincial agencies have required local governments to implement each agency's area of responsibility through the local planning process. As these agency interests overlap one another, little latitude is left for the municipalities to address local needs. This is very significant and leads to the need for a fundamental reevaluation of how rural planning is conducted. Senior governments will have to give greater priority to helping local government plan for serviced development and to assist municipalities in developing strategies to prevent groundwater quality problems and very dispersed settlement patterns.

If lot sizes are simply increased to address the concerns raised by this study, vast rural areas will be consumed by ever larger lots if current development rates continue using conventional sewage disposal technology.

This study represents a beginning, not an end. Much more work needs to be done to address the issues raised in an equitable manner.

The information currently available does not allow the prediction of a total rural development capacity based on groundwater. Considerably more information is necessary and the systems to collect, compile and use this information are not in place at present.

9.6 Recommendations

1. The Regional Municipality of Ottawa-Carleton should take a leadership role in the study area and further refine, manage and supplement the information contained in the Aquifer Management System. Although the Ontario Water Resources Act states that the Minister of the Environment is responsible for the supervision of all groundwater in Ontario, the Planning Act assigns responsibility to local government to ensure the health and safety of the future inhabitants. Increasingly, the results of inaction are likely to be costs borne by local taxpayers. The Regional Municipality of Ottawa-Carleton is in the process of setting up its own Geographically Referenced Information System (GRIS). A logical next step is to incorporate the aquifer management system in the GRIS and to continue to upgrade the aquifer management system within the GRIS tool. The Regional Municipality should make the information generated available to the Health Units and abutting municipalities. At an appropriate time in the future, the Health Units may wish to establish their own systems.

2. The Regional Municipality of Ottawa-Carleton should consider employing its own qualified hydrogeologist. The management of the study area's groundwater resources requires the attention of qualified individuals who can conduct relevant research, collate data, produce useful results, monitor well construction, sewage disposal system installations and septage application/disposal sites, coordinate public education programs or develop new programs such as sewage disposal system remediation or mandatory inspection of systems when a home is resold and generally deal with the multitude of matters which ultimately impact upon the sustainable use of groundwater resources. Some of the costs could be recouped through application fees or inspection fees.

3. The Ministry of the Environment should increase its efforts to conduct research on alternative sewage treatment technologies and assist the municipalities in the development of effective policy approaches.

4. While isolated groundwater problems exist, there is not such a sense of urgency that drastic measures such as Interim Control By-laws are required. However, planning policies need to more comprehensively deal with groundwater protection than they have in the past.

5. The creation of small lots in Hamlets on private services should be immediately curtailed pending a full investigation of servicing implications.

6. The potential use of communal water systems in the rural area should be considered by the study area municipalities in location where site specific high yield capability is available since they offer the ability to be more closely controlled during construction, allow for ongoing monitoring by a public agency and provide an opportunity for communal treatment where required.

7. A terms of reference for adequate and reasonable hydrogeological investigations should be developed for the study area, in consultation with representatives of the hydrogeology firms working in the area. This is the approach used by the Regional Municipality of Waterloo in developing its terms of reference.

8. There is a great need for Provincial sensitivity to the problems of local land use planning, requiring more assistance and less obstructionism, and recognizing the legitimate growth pressures which exist. Cooperative leadership is required and consistency in the way that Ministry policies are applied throughout the study area (inside RMOC and outside). It is a paradox that Provincial assistance is more readily available for groundwater clean up than it is for prevention. It is strongly recommended that the Provincial Government give serious consideration to assistance programs for serviced development, rather than limiting itself to partial assistance for the expansion of overloaded servicing systems.

9. A strict licensing procedure should be developed to ensure that all new wells are tested and all investigation results are submitted to the Regional Hydrogeologist. This will help ensure a complete database.

10. A licensing procedure should be developed to ensure that handlers/users of potential contaminants exercise an appropriate level of caution.

11. Approval policies for privately serviced development should focus on environmental compatibility, based on continuing research. Mitigation and buffering techniques should be explored. The purchase of down gradient development rights could be considered or designs could ensure that only parks and open space uses occur in potential impact areas. Phases smaller than 40 lots should be considered (about 20 lots) with detailed monitoring policies enforced as a prerequisite to additional development.

12. A comprehensive well water survey should be undertaken in the study area to determine the overall status of drinking water quality.

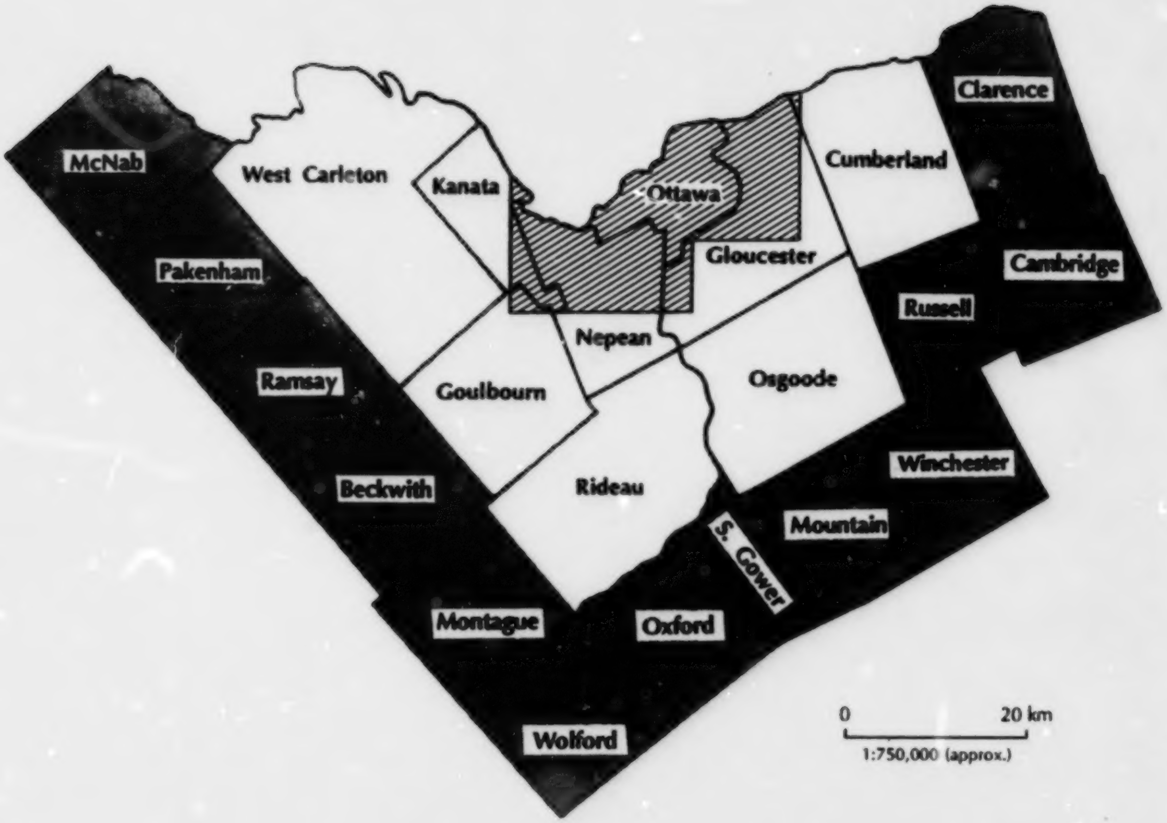
13. A monitoring program should be established to determine whether private sewage disposal systems in approved subdivisions are performing in the manner predicted by the hydrogeology studies.

14. Well head protection measures should be undertaken to ensure that existing communal water supply systems can continue to function safely and economically.

15. Subdivision application forms and applicant guidelines should be revised to stress the importance of adequate hydrogeological information at the earliest stages of the rural development process.

16. Multiple consents should be severely limited. The consent process was simply not designed to deal with the complexities of multiple lot developments. The subdivision process requires corresponding improvement so that the multiple consent process is not such an attractive alternative.

17. The creation of single lots by consent should involve the collection of basic information on soil type, groundwater flow direction and proximity to wells and sewage disposal systems on neighbouring lots in areas where development exists or is anticipated. In isolated circumstances, such as a farm retirement lot, or for very large lots, this information may be less critical. There is no technical justification for the creation of inferior lots through the consent process.


McNab
West Carleton
Kanata
Ottawa
Cumberland
Clarence
Pakenham
Gloucester
Cambridge
Russell
Nepean
Ramsay
Goulbourn
Osgoode
Winchester
Beckwith
Rideau
S. Gower
Mountain
Montague
Oxford
Wolford
0
20 km
1:750,000 (approx.)

▨ URBAN AREA EXCLUDED FROM STUDY AREA

☐ REGIONAL MUNICIPALITY OF OTTAWA-CARLETON

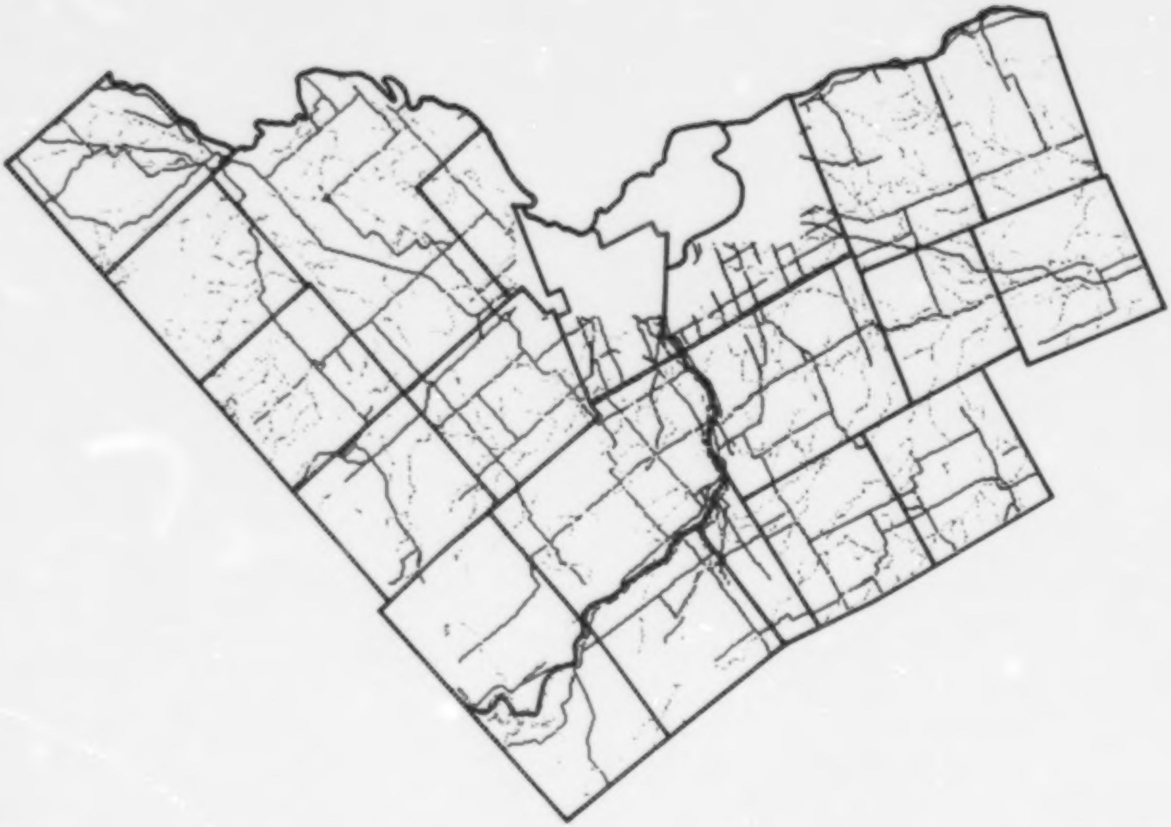
■ TOWNSHIPS SURROUNDING RMOC

Figure 1a

Study Area Map

GEO-ANALYSIS

Project No. G9105



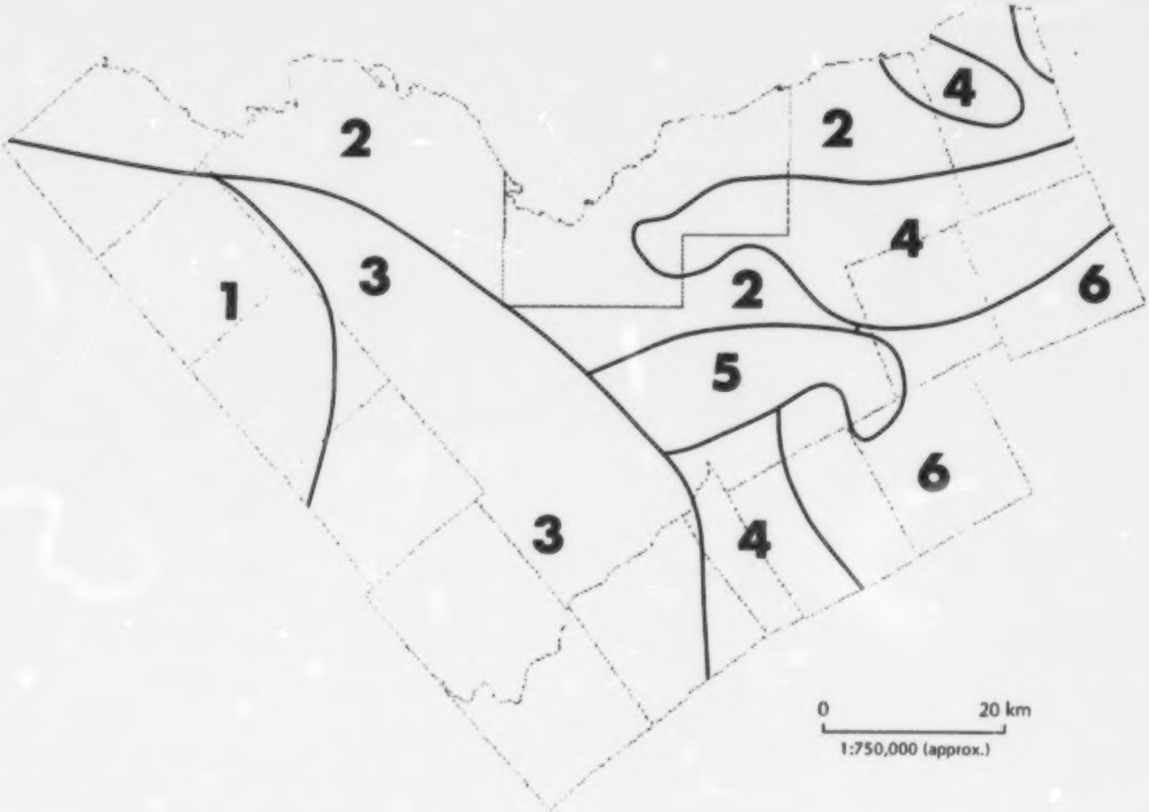
Data Source: EMR Digital Data: Sheet No.s 31B, 31C, 31F and 31G

Figure 1b

Hydrographic and Culture Overlay

GEO ANALYSIS

Project No. G9105


2
4
2
4
3
1
2
6
5
6
3
4
0
20 km
1:750,000 (approx.)

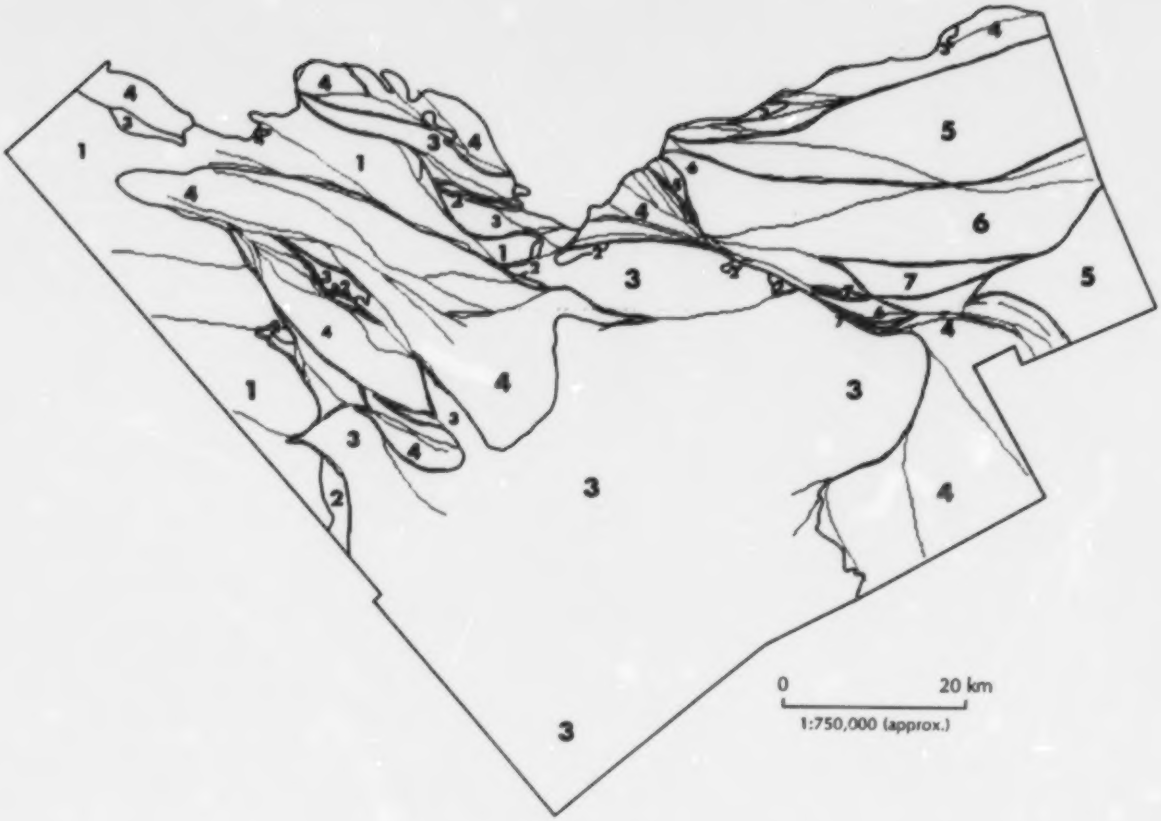
1	Algonquin highlands
2	Ottawa Valley clay flats
3	Smiths Falls limestone plain
4	Edwardsburg, Prescott and Russell sand plains
5	North Gower drumlin field
6	Winchester clay plain

After: L.J. Chapman and D.F. Putman, 1984

Figure 2a

Physiographic Regions

Project No. G9105



BEDROCK GEOLOGY

7	RED SHALES
6	GREY SHALES
5	INTERBEDDED LIMESTONE & SHALE
4	LIMESTONE and a little shale
3	DOLOMITE & LIMESTONE
2	SANDSTONE
1	IGNEOUS AND METAMORPHIC
~	FAULTS

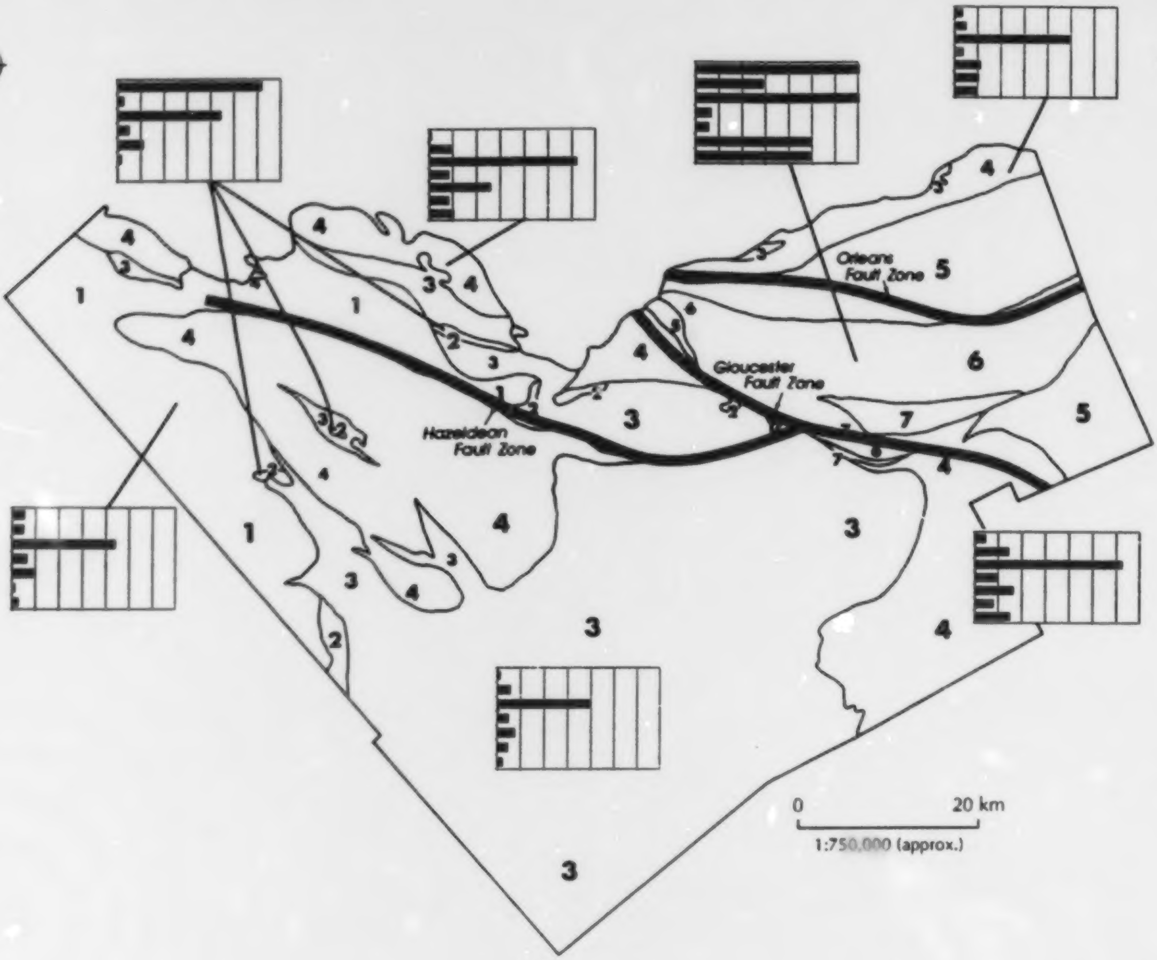
After: Williams and others (Ontario Geological Survey - Paleozoic Series)

Figure 3

Fault Zones & Bedrock Geology

GEO ANALYSIS

Project No. G9105

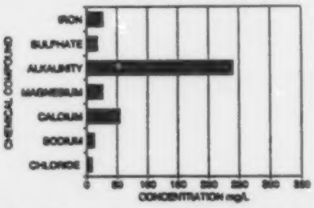

Orleans Fault Zone
Gloucester Fault Zone
Hazeldean Fault Zone
1
2
3
4
5
6
7
0
20 km
1:750,000 (approx.)

Data Source: Selected Hydrogeological reports submitted for subdivision approval.

	BEDROCK GEOLOGY	GIS RANKING
7	RED SHALES	4
6	GREY SHALES	4
5	INTERBEDDED LIMESTONE & SHALE	4
4	LIMESTONE and a little shale	2
3	DOLOMITE & LIMESTONE	1
2	SANDSTONE	1
1	IGNEOUS AND METAMORPHIC	3

After: Williams and others (Ontario Geological Survey - Paleozoic Series)

KEY FOR BAR GRAPHS



For illustration purposes, iron concentrations have been increased by a factor of 100

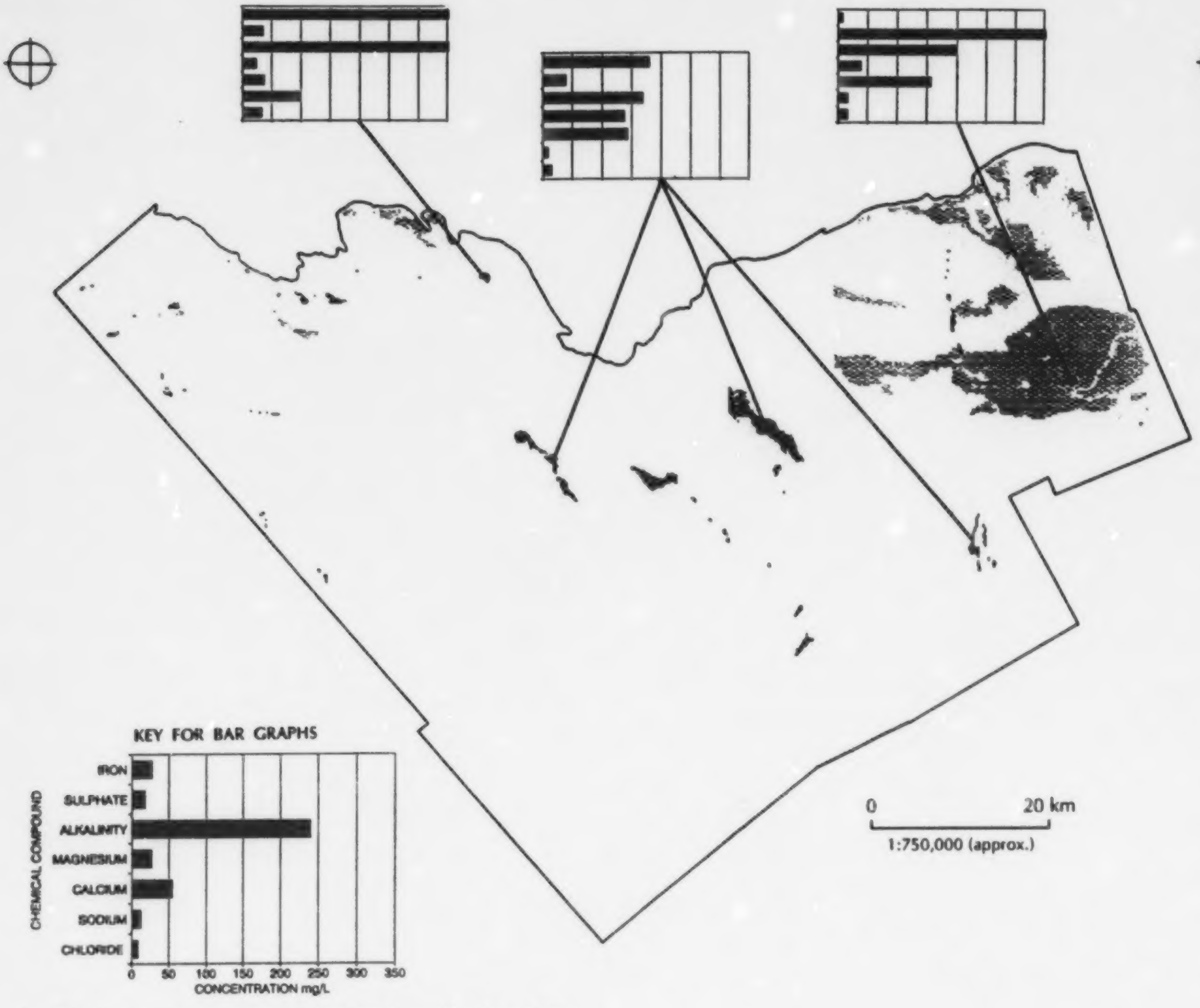
Water quality distribution is associated to typical aquifer blocks. Variations will occur locally.

Figure 4a

Water Quality Distribution of the Bedrock Aquifers

GEO ANALYSIS

Project No. G9105


KEY FOR BAR GRAPHS
IRON
SULPHATE
ALKALINITY
MAGNESIUM
CALCIUM
SODIUM
CHLORIDE
CHEMICAL COMPOUND
0
50
100
150
200
250
300
350
CONCENTRATION mg/L
0
20 km
1:750,000 (approx.)

For Illustration purposes, Iron concentrations have been increased by a factor of 100

	OVERBURDEN AQUIFERS	POTENTIAL	GIS RANKING
■	ICE CONTACT - stratified drift	High	1
▨	DELTAIC & ESTUARINE SEDIMENTS	Moderate	2
░	ALLUVIUM & NEARSHORE SEDIMENTS	Low	3
☐	Remaining Overburden Units & Bedrock Outcrops	Unclassified	4

Notes:

1- Basel Gravel Aquifer may be present in places.

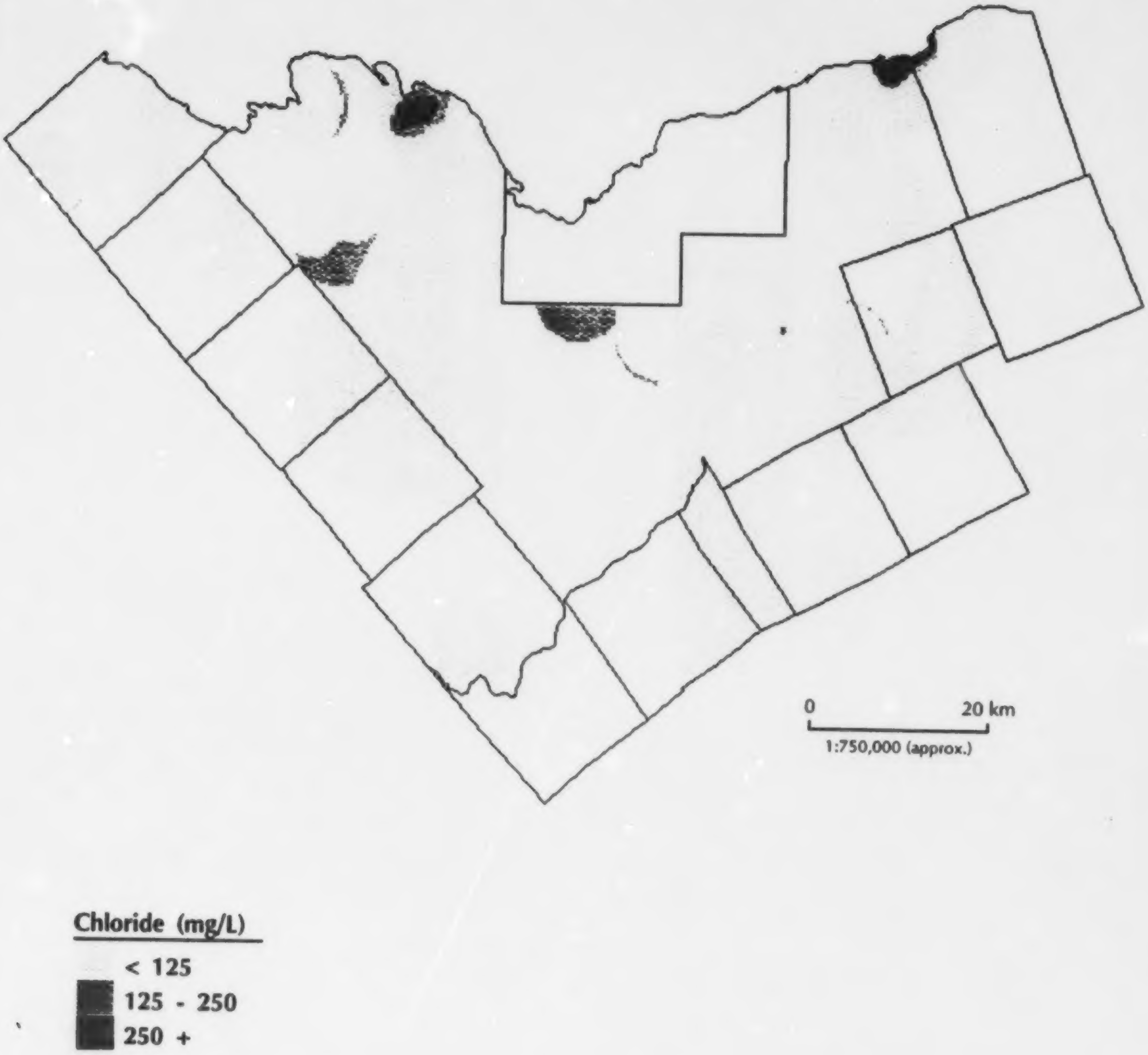
2- Saturated portions of Alluvium & Nearshore Sediments may limit its Overburden Potential.

Figure 4b

Water Quality Distribution of the Overburden Aquifers

GEO ANALYSIS

Project No. G9105


0
20 km
1:750,000 (approx.)
Chloride (mg/L)
< 125
125 - 250
250 +

Data Source:
Selected Hydrogeological Reports Submitted for Subdivision Approval.

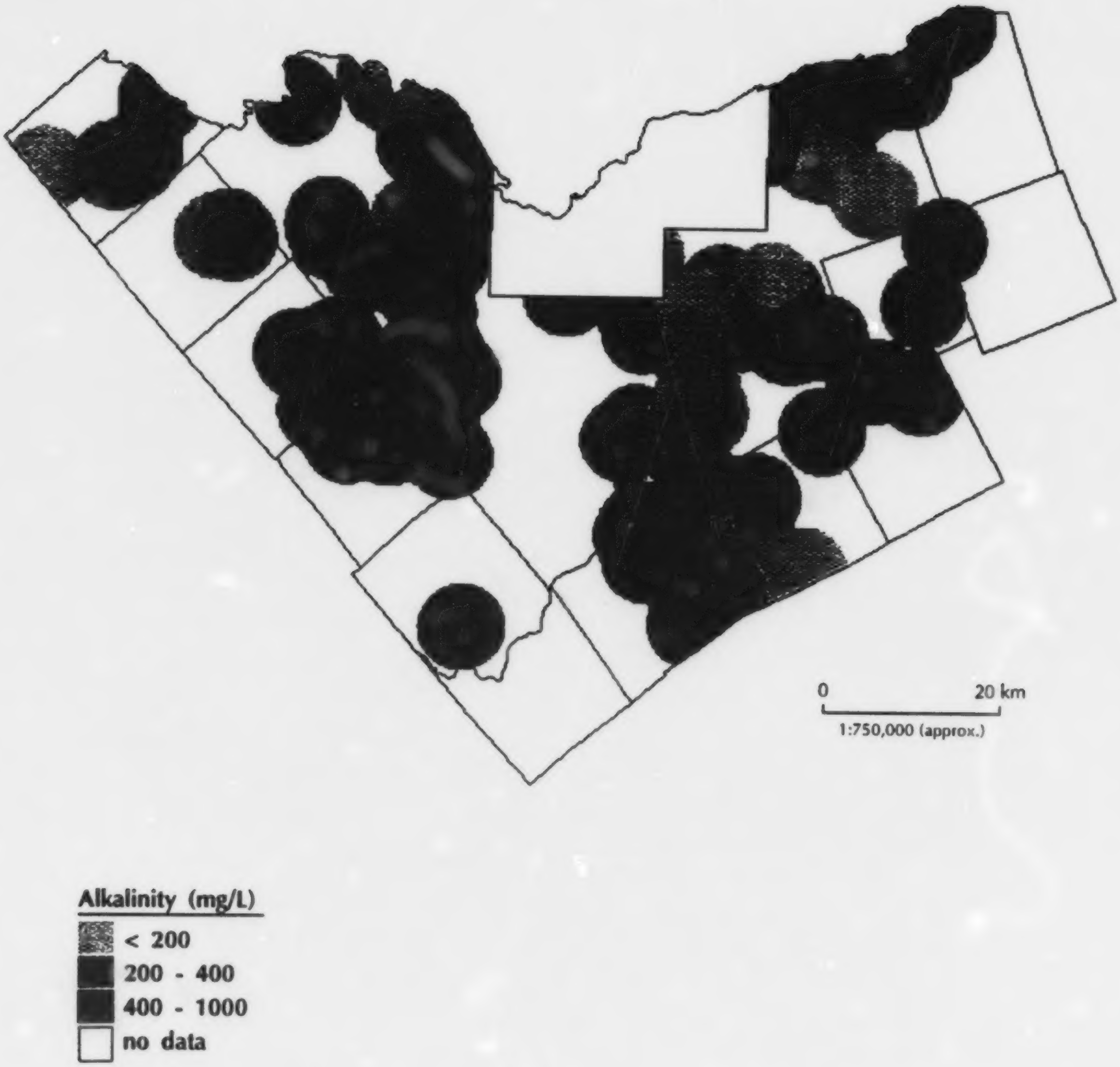
Note:
Each data point was assigned a 5 km radius of influence.

Figure 5a

Chloride Distribution (mg/L)

GEO-ANALYSIS

Project No. G9105


0
20 km
1:750,000 (approx.)
Alkalinity (mg/L)
▨ < 200
■ 200 - 400
■ 400 - 1000
☐ no data

Data Source: Selected Hydrogeological Reports Submitted for Subdivision Approval.

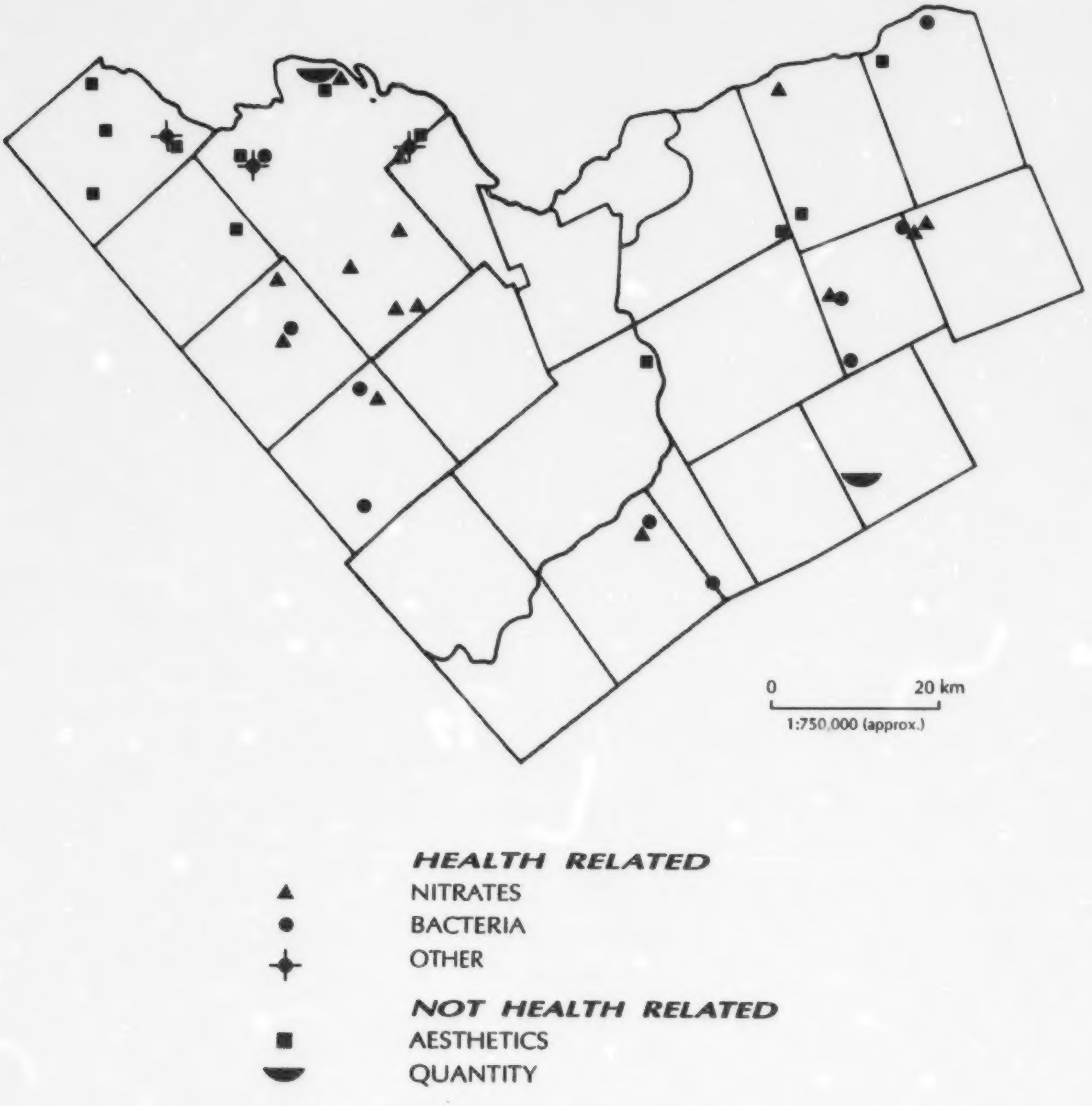
Note: Each data point was assigned a 5 km radius of influence.

Figure 5b

Alkalinity Distribution (mg/L)

GEO-ANALYSIS

Project No. G9105


0
20 km
1:750,000 (approx.)
HEALTH RELATED
▲ NITRATES
● BACTERIA
✦ OTHER
NOT HEALTH RELATED
■ AESTHETICS
◡ QUANTITY

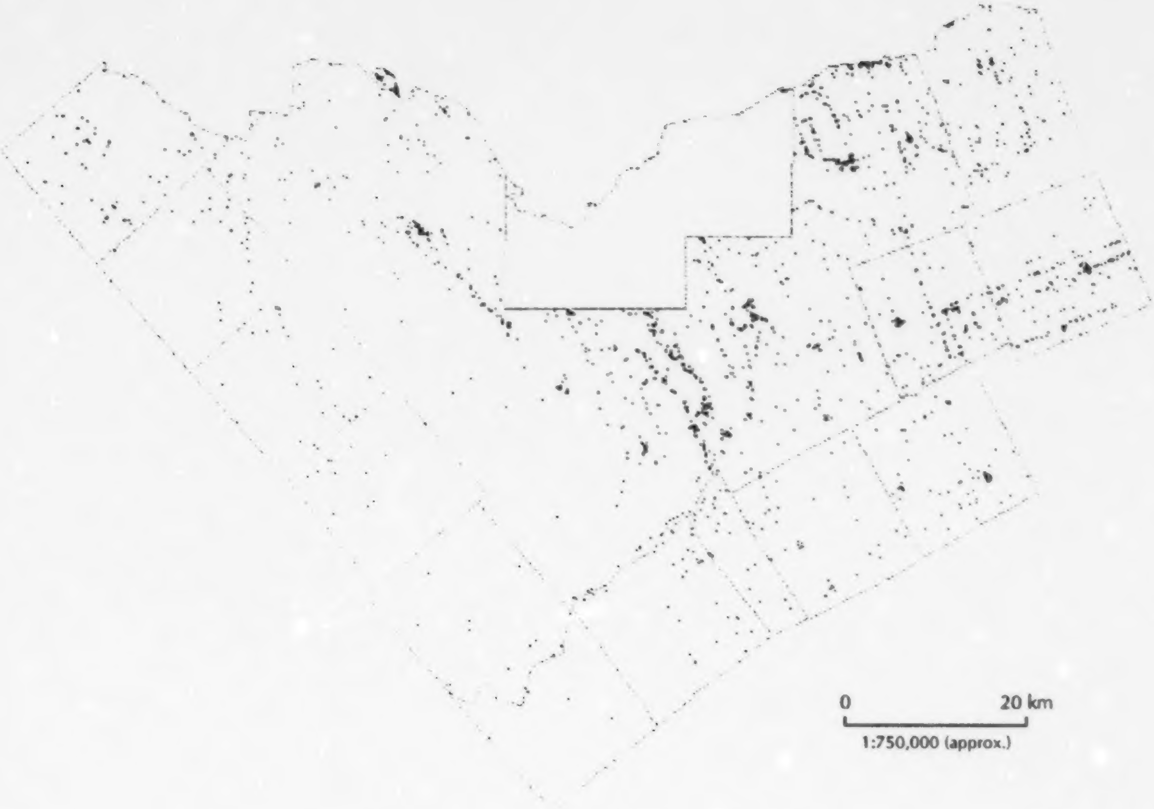
Data Source: Conversation with Part VII Directors.

Figure 6

Groundwater Quality Problems

GEO ANALYSIS

Project No. G9105



0
20 km
1:750,000 (approx.)

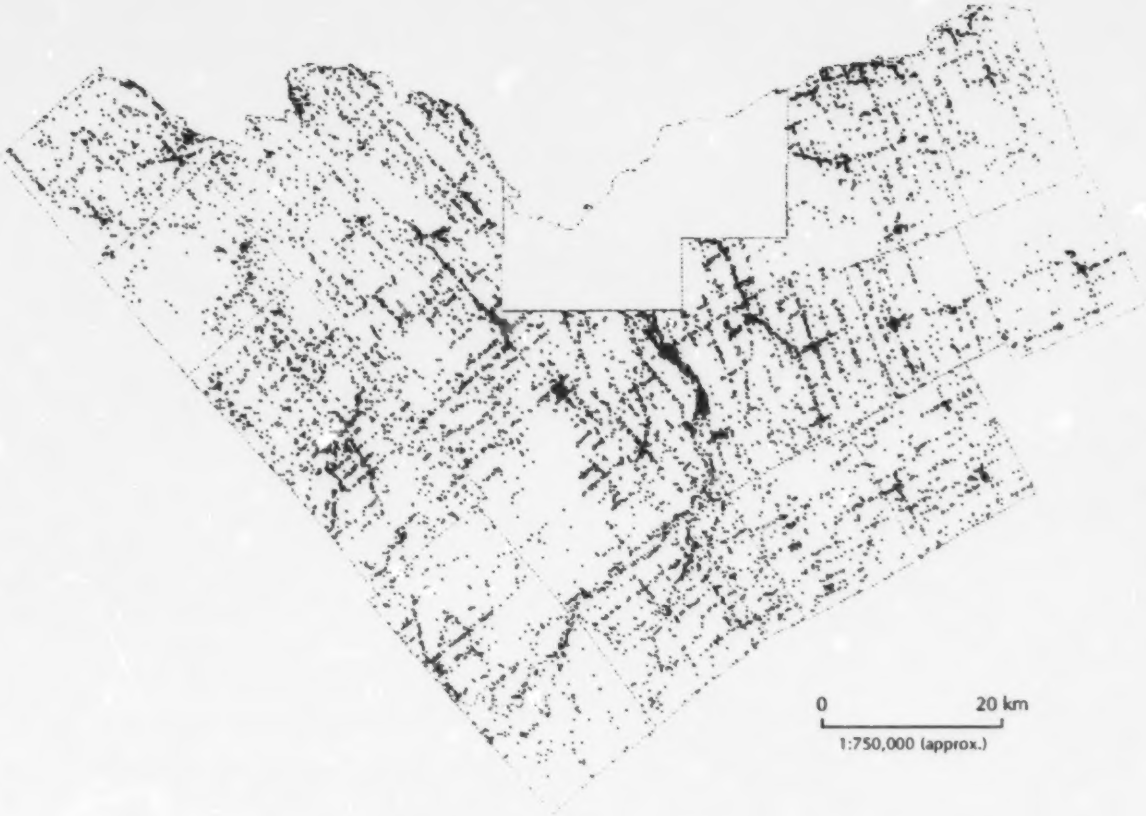
Data Source: MOE Waterwell Records (Approx. 2,000 wells)

Figure 7

Scatterplot of Overburden Wells

GEO ANALYSIS

Project No. G9105


0
20 km
1:750,000 (approx.)

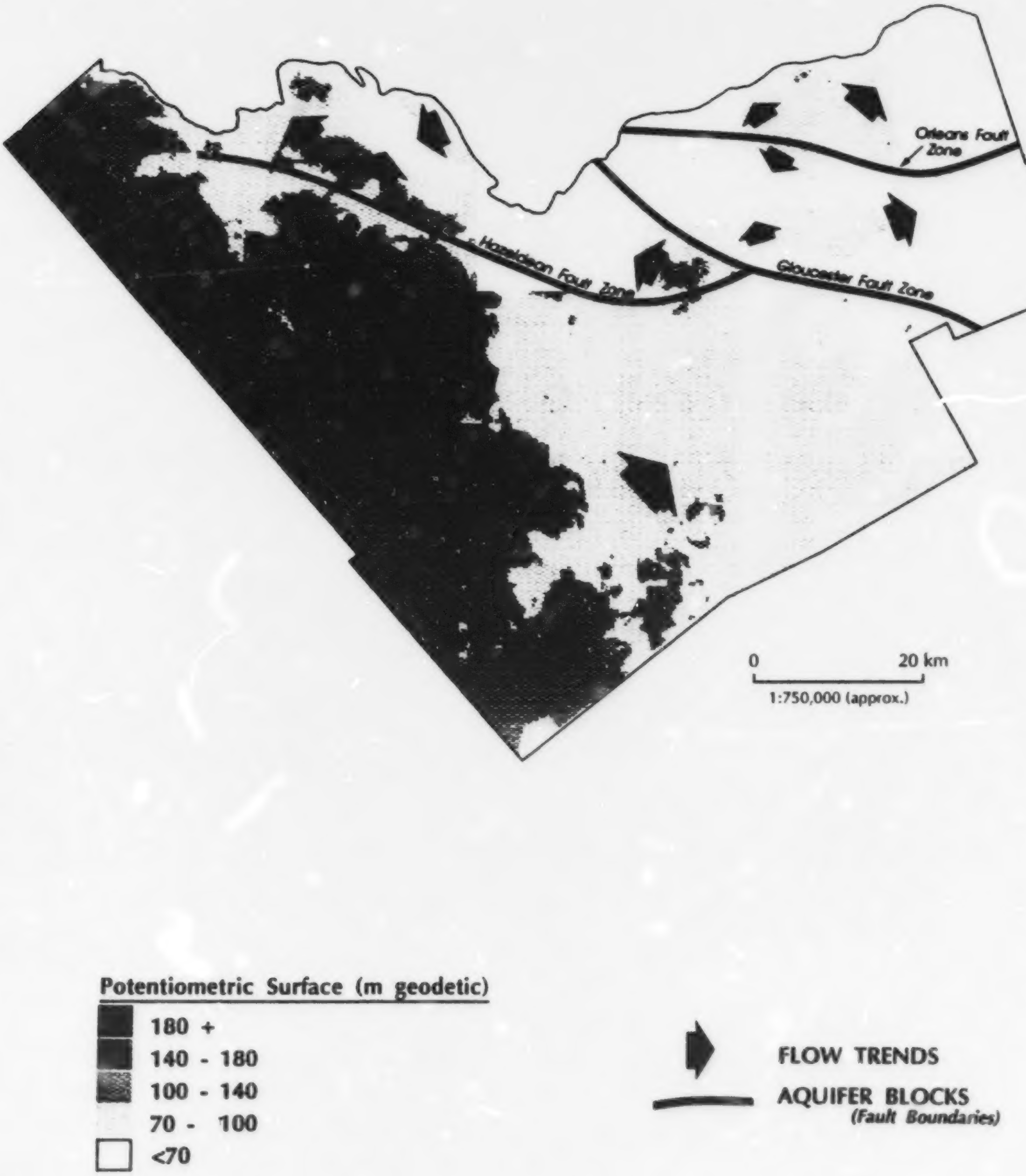
Data Source:
MOE Waterwell Records (Approx.18,000 wells)

Figure 8a

Scatterplot of Bedrock Wells

GEO ANALYSIS

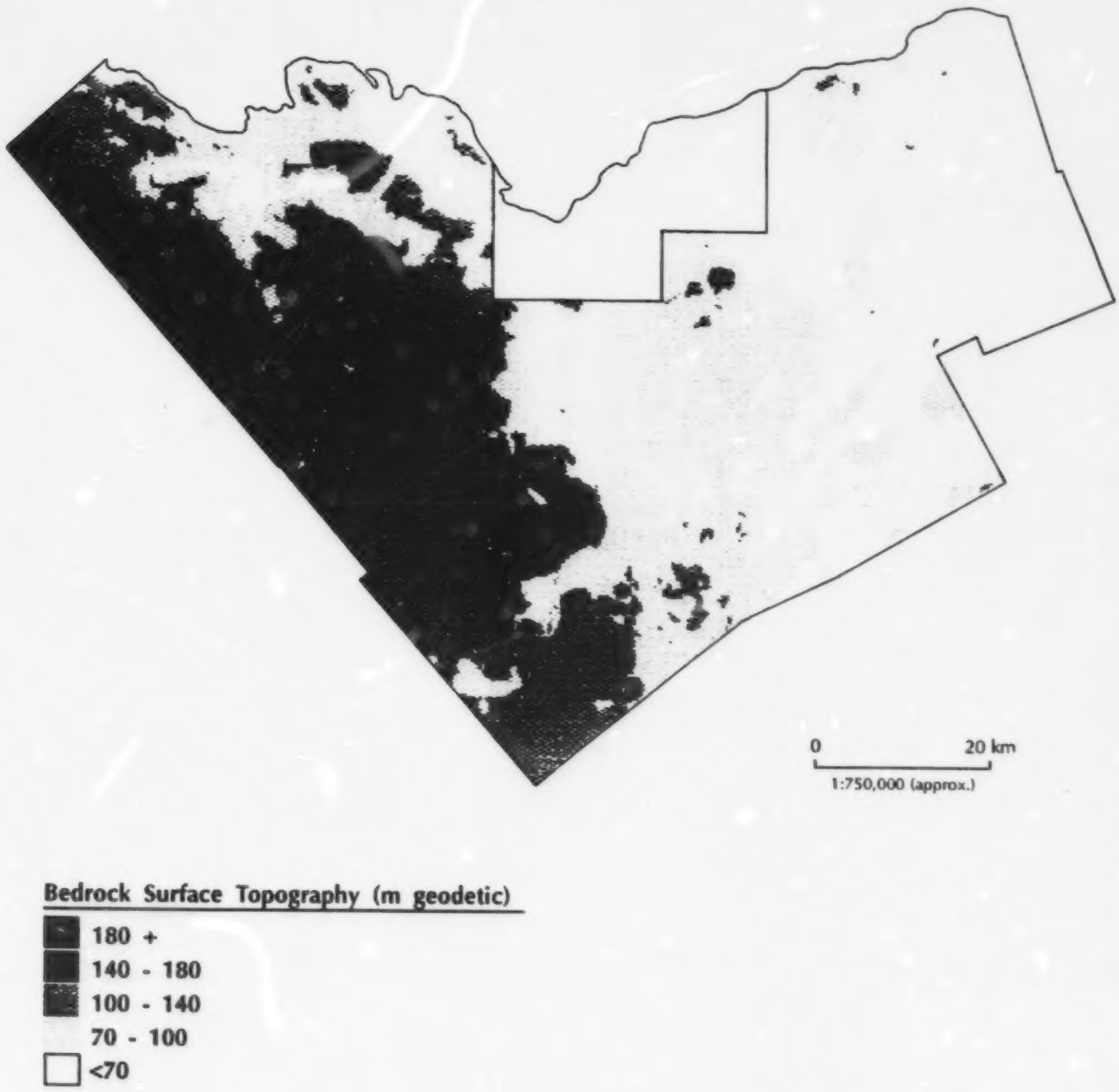
Project No. G9105


Orleans Fault Zone
Hazeldean Fault Zone
Gloucester Fault Zone
0
20 km
1:750,000 (approx.)
Potentiometric Surface (m geodetic)
180 +
140 - 180
100 - 140
70 - 100
<70
FLOW TRENDS
AQUIFER BLOCKS
(Fault Boundaries)

Data Source:
MOE Waterwell Records (Approx.18,000 wells)

Figure 8b
Potentiometric Head of Bedrock Aquifer and Groundwater Flow Trends

Project No. G9105

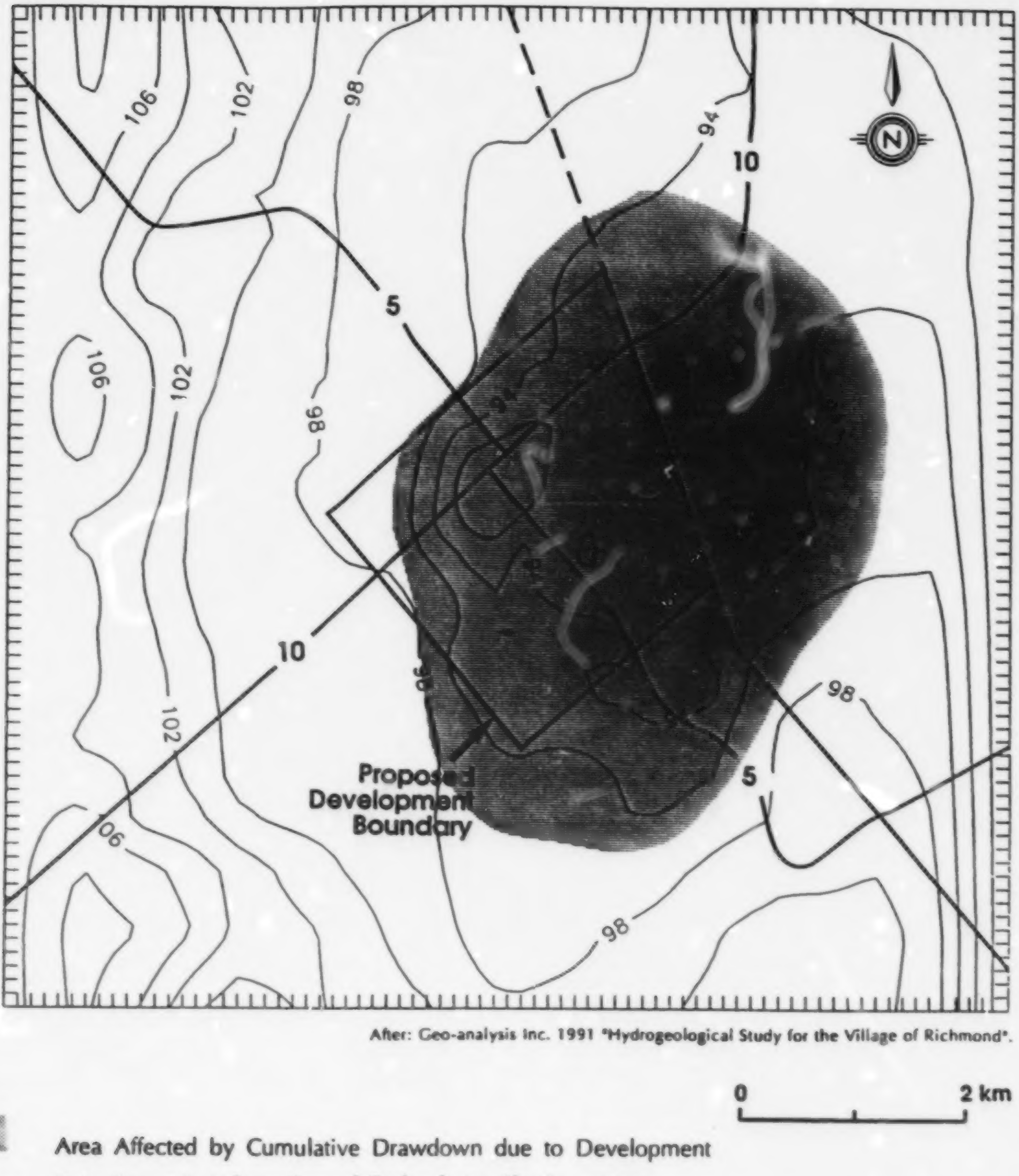

0
20 km
1:750,000 (approx.)
Bedrock Surface Topography (m geodetic)
▩ 180 +
■ 140 - 180
▨ 100 - 140
70 - 100
☐ <70

Data Source:
MOE Waterwell Records (Approx.18,000 wells)

Figure 9

Bedrock Surface Topography

Project No. G9105


106
102
98
94
10
5
106
102
98
94
98
10
102
98
98
5
106
98
N
Proposed Development Boundary

After: Geo-analysis Inc. 1991 "Hydrogeological Study for the Village of Richmond".

0 2 km

▨ Area Affected by Cumulative Drawdown due to Development

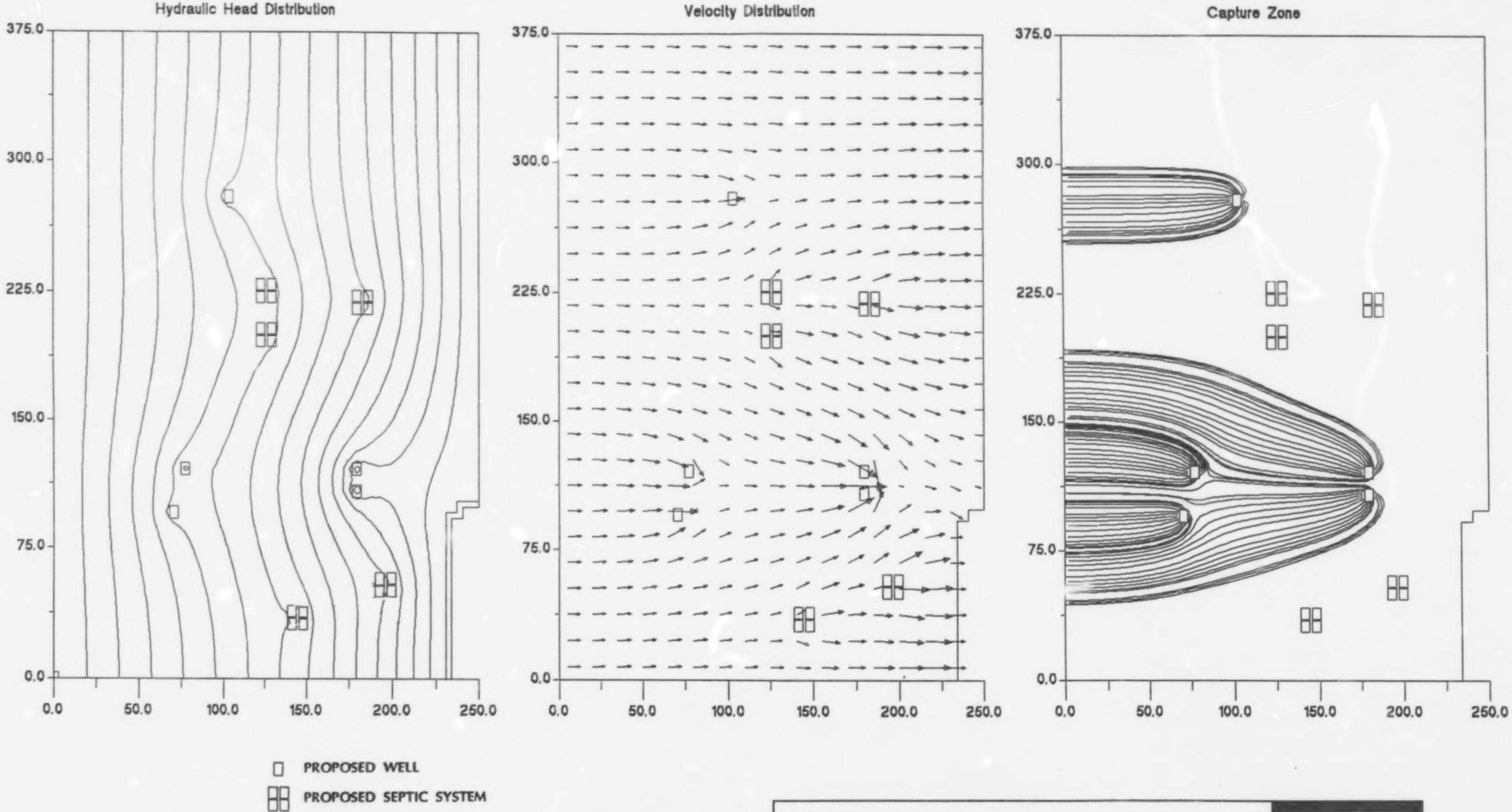
—94— Potentiometric Information of Bedrock Aquifer in metres

Figure 10

Cumulative Hydraulic Impact of Development on a Bedrock Aquifer

GEO ANALYSIS

Project No. G9105



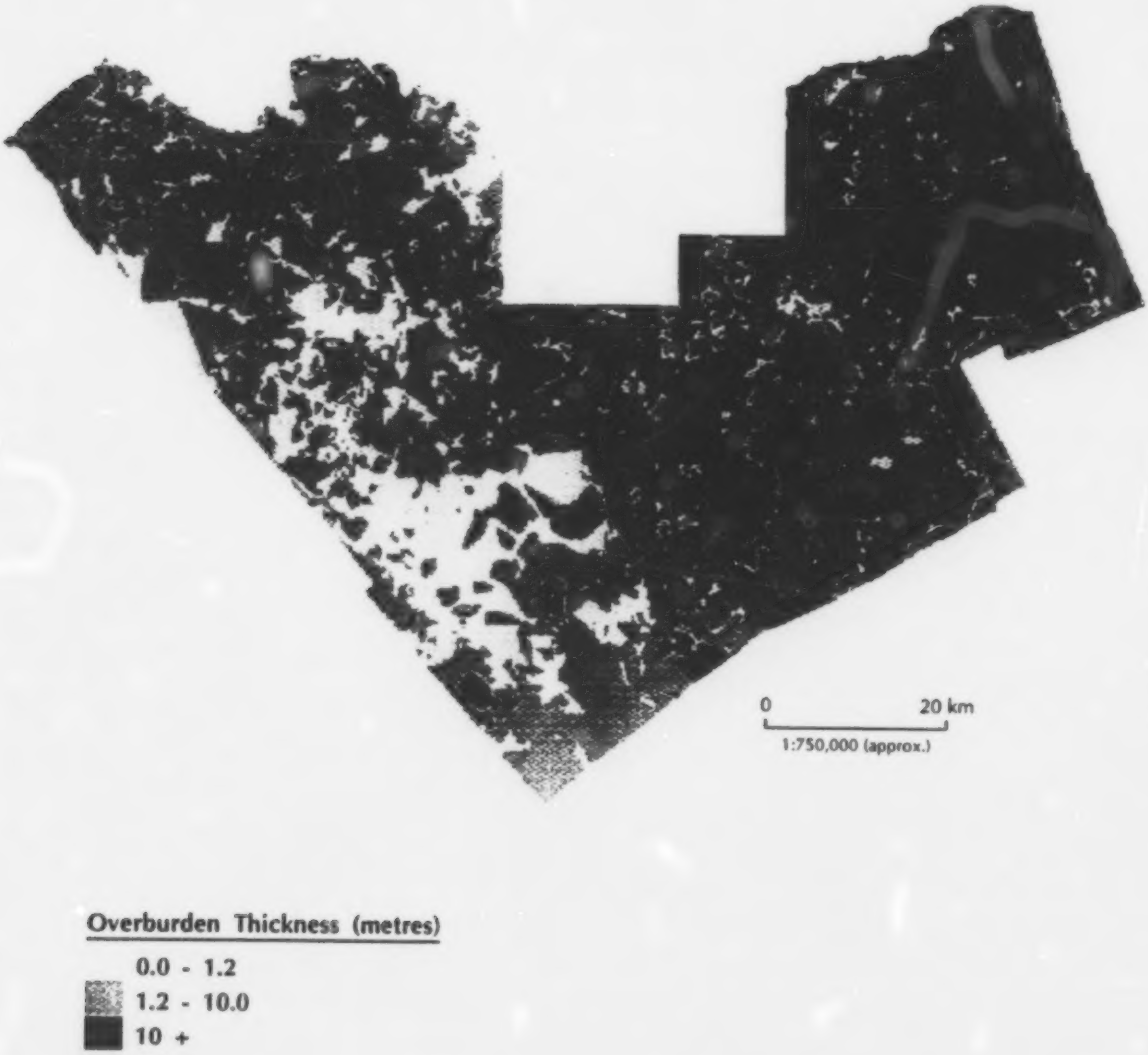
From: Geo-analysis Inc. 1991. Example of Proposed Subdivision near Limoges.

Figure 11

Well Capture Zone Delineation on a Sand Aquifer

GEO-ANALYSIS

Project No. G9105


0
20 km
1:750,000 (approx.)
Overburden Thickness (metres)
0.0 - 1.2
▨ 1.2 - 10.0
■ 10 +

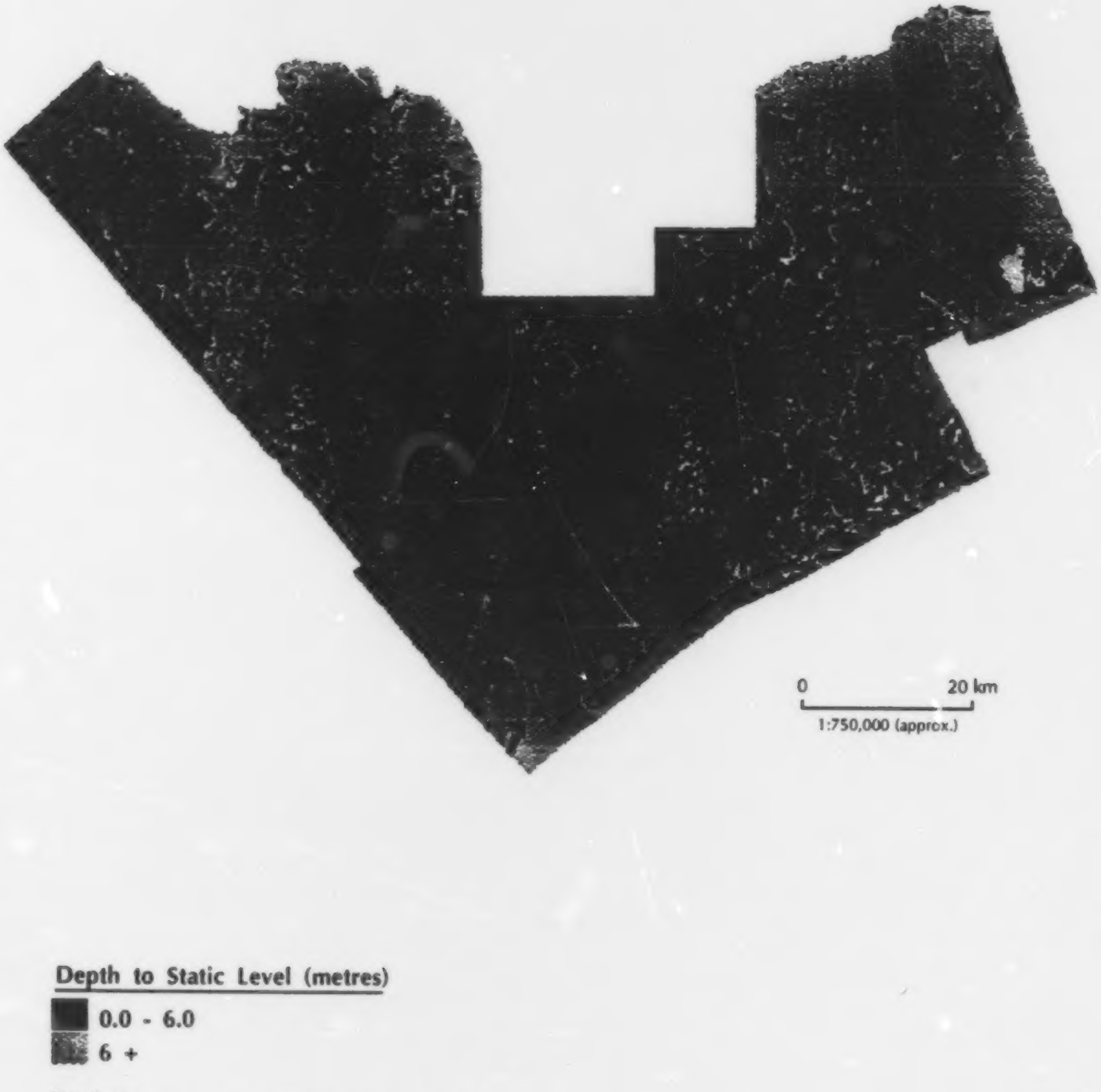
Data Source: MOE Waterwell Records (current to 1985)

Figure 12

Overburden Thickness

GEO-ANALYSIS

Project No. G9105


0
20 km
1:750,000 (approx.)
Depth to Static Level (metres)
■ 0.0 - 6.0
▨ 6 +

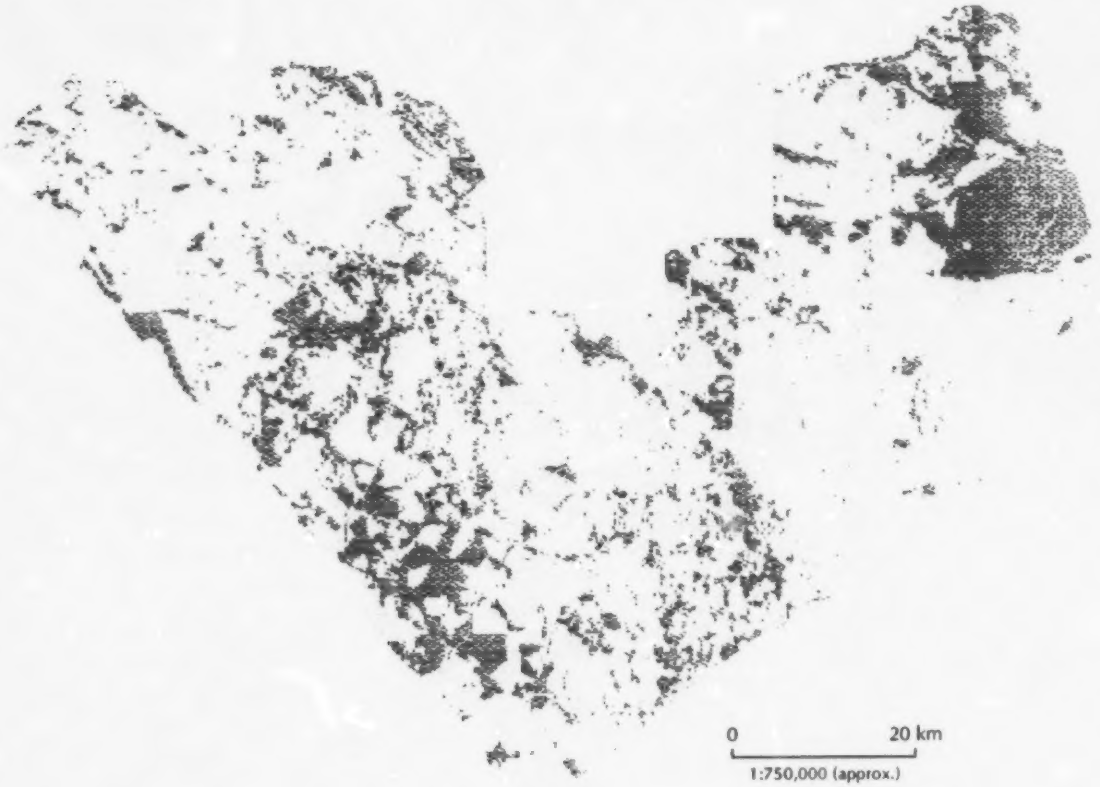
Data Source:
MOE Waterwell Records (current to 1985)

Figure 13

Depth to Bedrock Aquifer Static Levels

GEO-ANALYSIS

Project No. G9105



Recharge Probability

- ■ VERY HIGH
- ▩ HIGH
- ░ MODERATE
- ☐ LOW

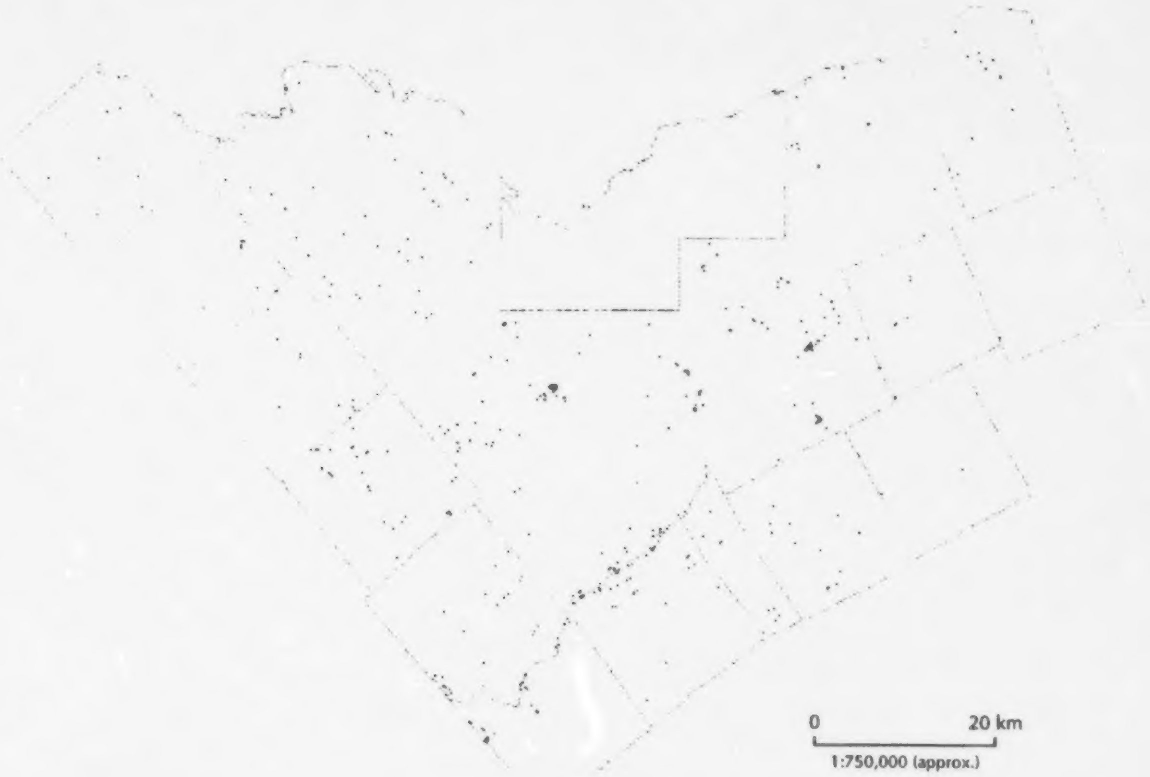
Data Source:
MOE Waterwell Records (current to 1985)

NOTE:
See Appendix G for Modelling Methodology

Figure 14
Bedrock Aquifer Groundwater Recharge Probability Map

GEO ANALYSIS

Project No. G9105


0
20 km
1:750,000 (approx.)

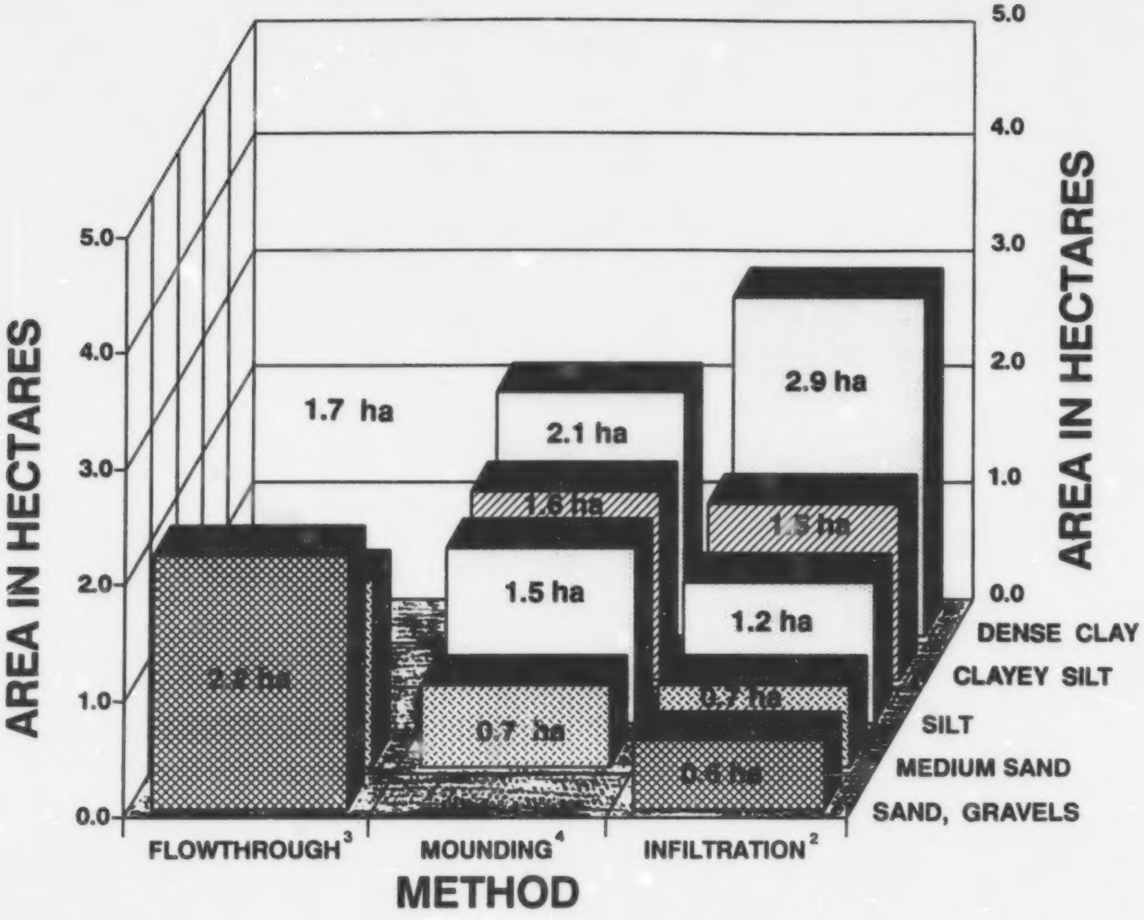
Data Source:
MOE Waterwell Records (Approx. 450 wells) [current to 1985]

Figure 15

Scatterplot of Flowing Bedrock Wells

GEO-ANALYSIS

Project No. G9105



NOTES:

1) Figure is for general illustration. Lot size should be determined on site specific conditions.

2) - Computed for 10.0 mg/L Nitrate as N.
- INFILTRATION method after MOE Central Region (1991).

3) - Computed for 2.5 mg/L Nitrate as N on 10m thick saturated soils.
- FLOWTHROUGH based on MOC Modelling.

4) - For mounding calculation based on:
  - 10m overburden thickness for sand, granules and medium sand.
  - 5m overburden thickness for silt.
  - 2m overburden thickness for clayey silt and clay.

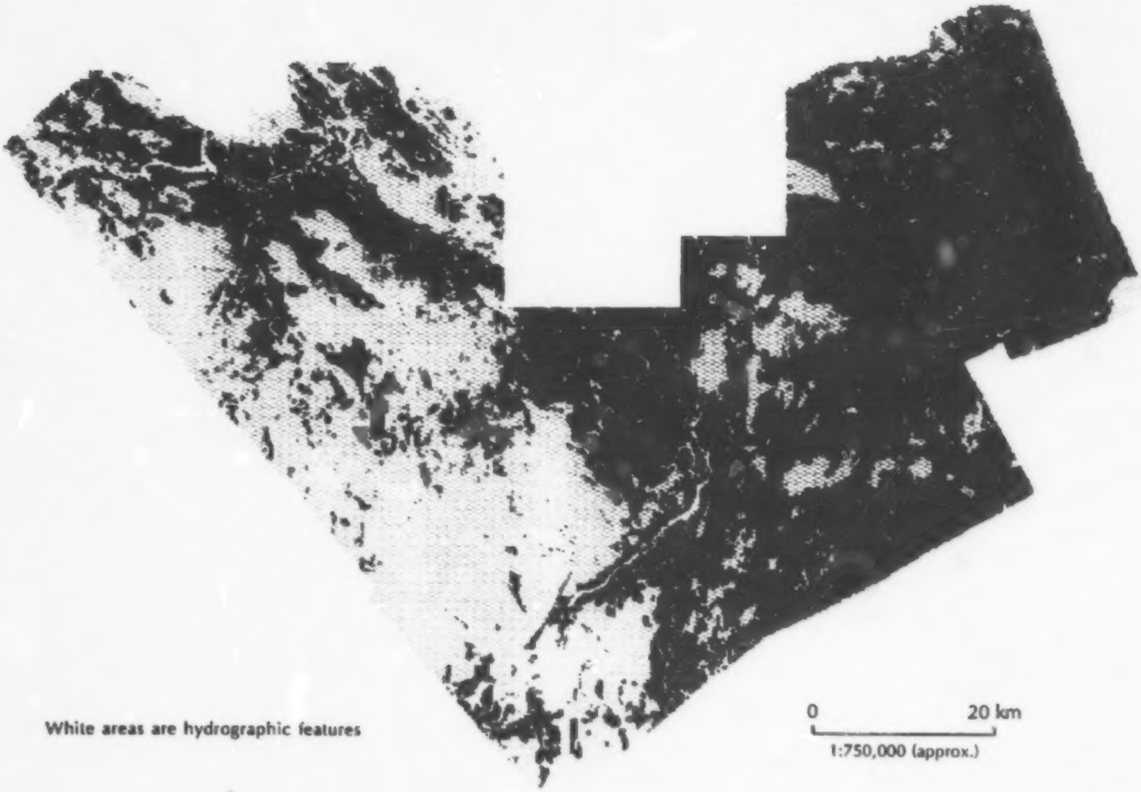
- MOUNDING based on MODFLOW Modelling.

Figure 16

Lot Size vs Methodology

GEO-ANALYSIS

Project No. G9105



White areas are hydrographic features

	TERRAIN SUITABILITY	GIS RANKING
■	HIGH	1
■	MODERATE	2
▨	LOW	3
░	VERY LOW	4

NOTES:

1) Classification is based on protecting the underlying Aquifer.

2) The modelled overburden thickness does not take into account the stratigraphic sequence. Site specific studies are required and may vary from the above classification.

3) Based on conventional septic systems.

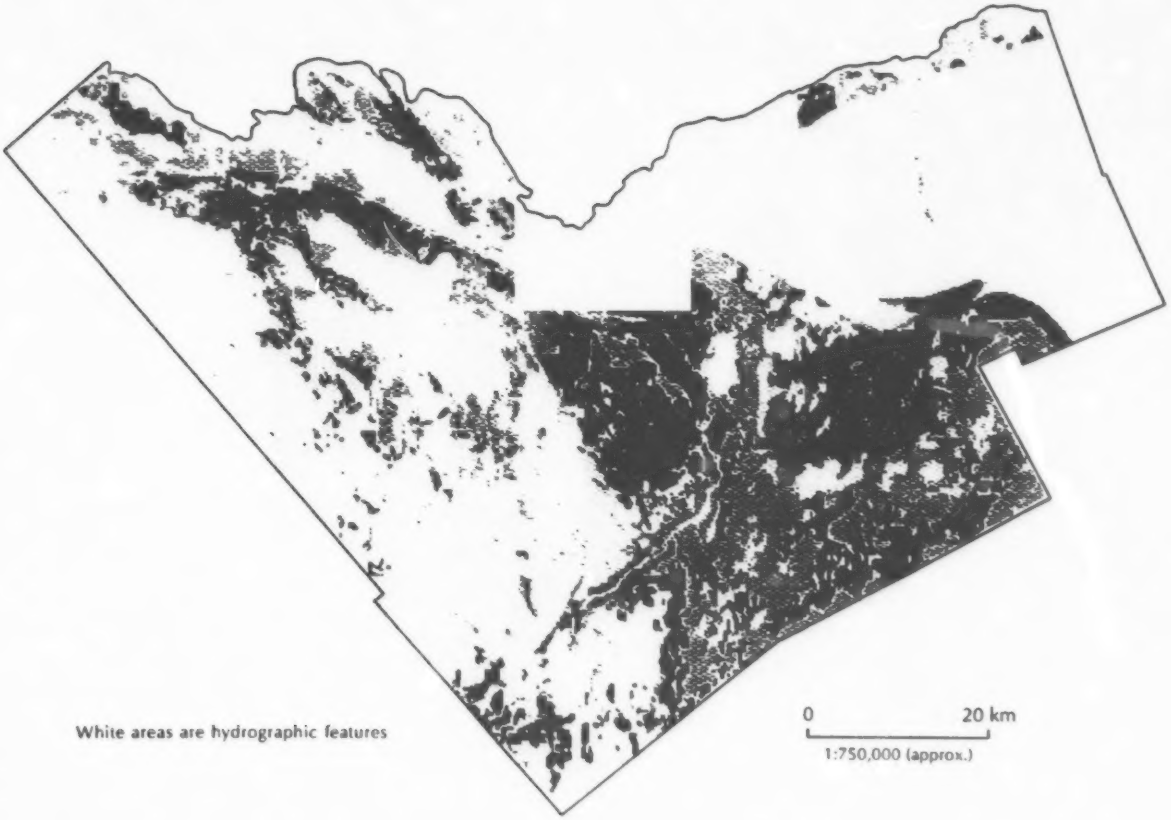
4) See Appendix H for Modelling Methodology

Figure 17

Terrain Suitability Potential for Septic Systems

GEO ANALYSIS

Project No. G9105



White areas are hydrographic features
0
20 km
1:750,000 (approx.)

	DEVELOPMENT POTENTIAL	GIS RANKING
■	HIGH	1
▨	MODERATE	2
	LOW	3

NOTE:
1) See Appendix I for Modelling Methodology.
2) Figure based on Aquifer Potential and Terrain Suitability.

Figure 18

Development Potential Map

GEO-ANALYSIS

Project No. G9105

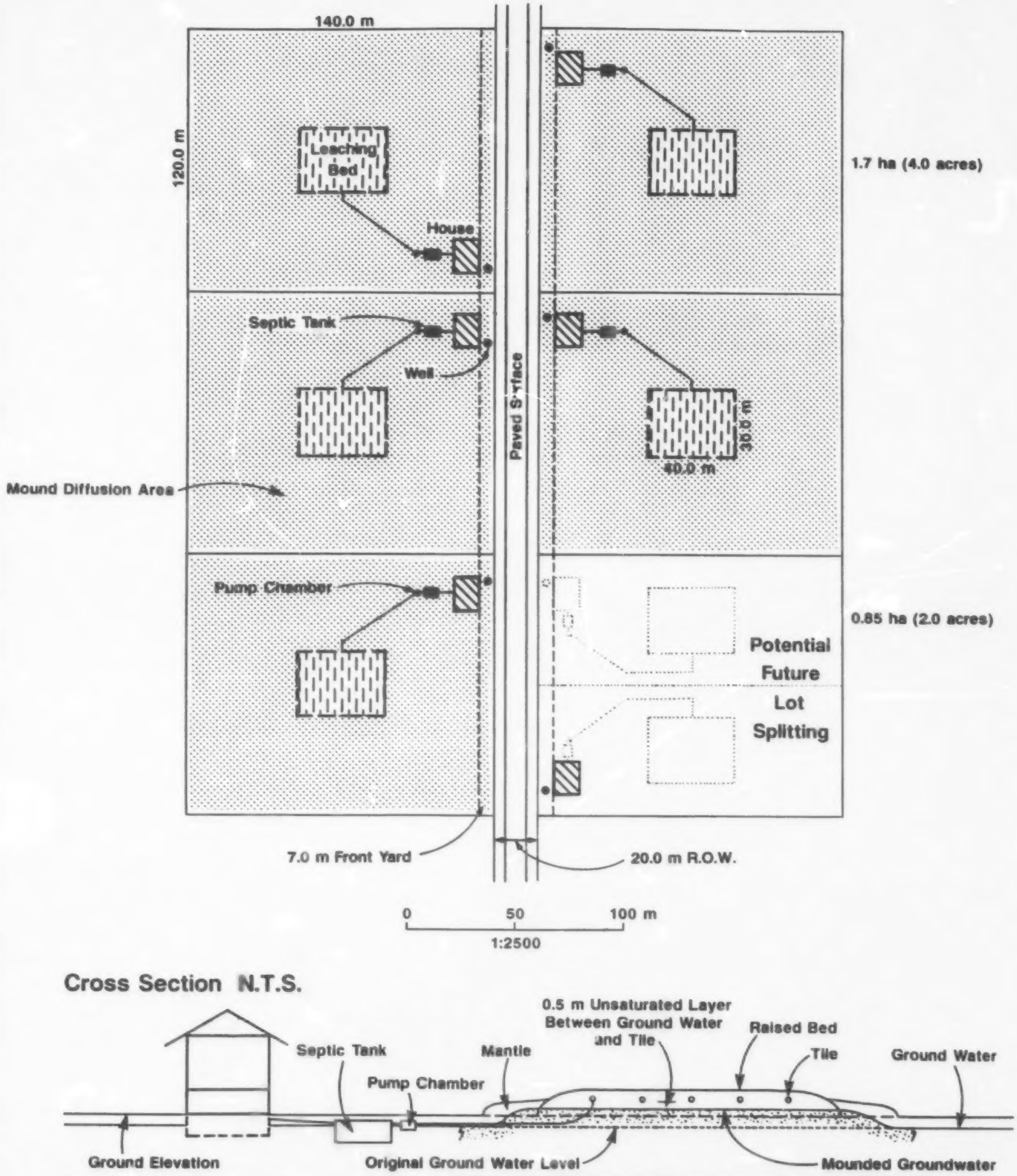

140.0 m
120.0 m
Leaching Bed
House
Septic Tank
Well
Paved Surface
Mound Diffusion Area
Pump Chamber
30.0 m
40.0 m
1.7 ha (4.0 acres)
0.85 ha (2.0 acres)
Potential Future Lot Splitting
7.0 m Front Yard
20.0 m R.O.W.
0
50
100 m
1:2500
Cross Section N.T.S.
Septic Tank
Pump Chamber
Mantle
0.5 m Unsaturated Layer Between Ground Water and Tile
Raised Bed
Tile
Ground Water
Ground Elevation
Original Ground Water Level
Mounded Groundwater

Figure 19 Conceptual Development Pattern Resulting From Figure D-I-8

J.L.Richards & Associates Limited
Consulting Engineers, Architects & Planners

J.L.R. No. 12345

(Mounding Simulation on Clay)

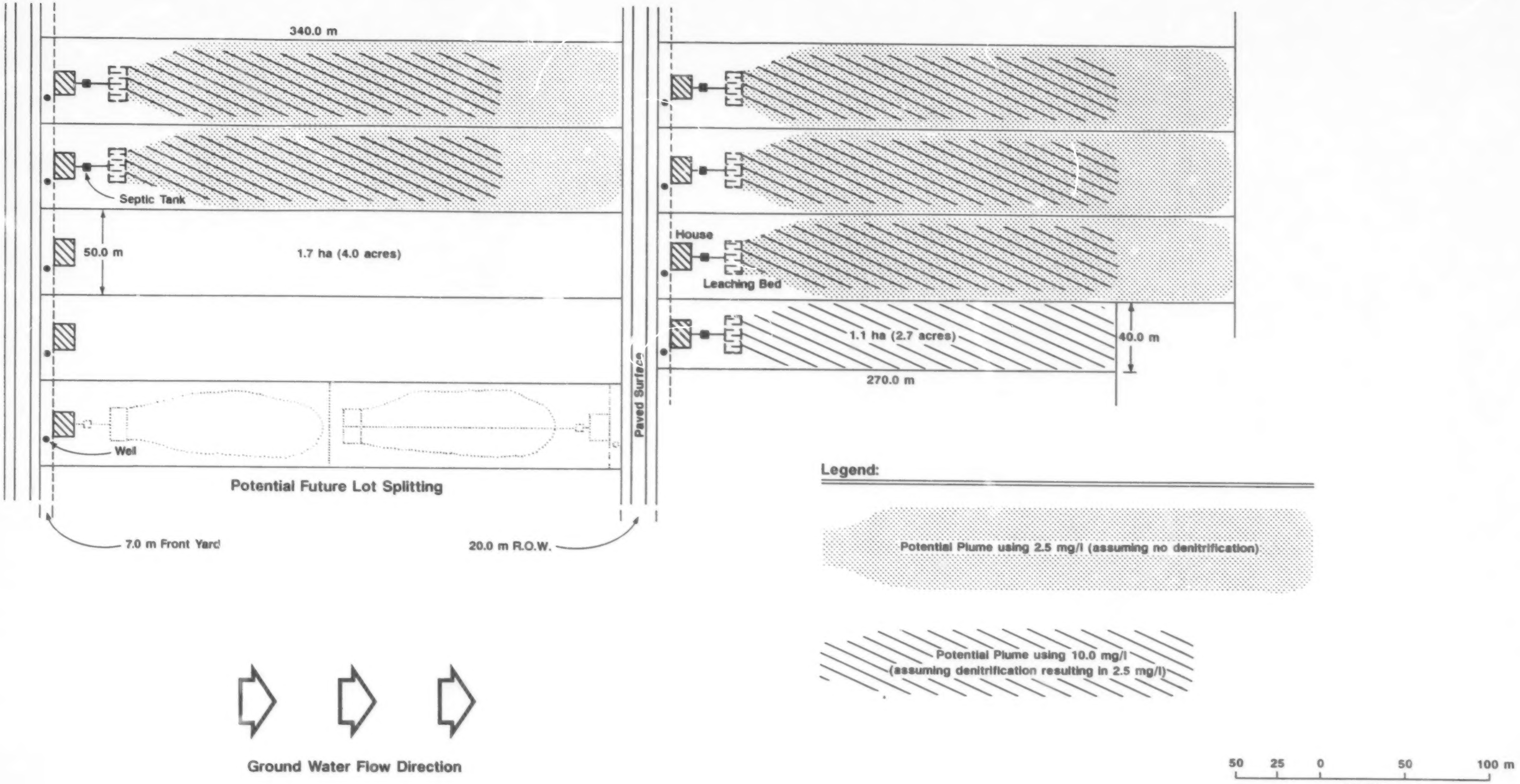

340.0 m
Septic Tank
50.0 m
1.7 ha (4.0 acres)
Well
Potential Future Lot Splitting
7.0 m Front Yard
20.0 m R.O.W.
Paved Surface
House
Leaching Bed
1.1 ha (2.7 acres)
40.0 m
270.0 m
Legend:
Potential Plume using 2.5 mg/l (assuming no denitrification)
Potential Plume using 10.0 mg/l (assuming denitrification resulting in 2.5 mg/l)
Ground Water Flow Direction
50 25 0 50 100 m
1:2500

Figure 20
Conceptual Development Pattern Resulting From Figure D-II-3

(Nitrate Plume Simulation on Sand)

J.L.Richards & Associates Limited
Consulting Engineers, Architects & Planners

J.L.R. No. 12345

TABLE 1
BEDROCK STRATIGRAPHY RMOC AND ABUTTING TOWNSHIPS

PERIOD	FORMATION	LITHOLOGY*	MAXIMUM THICKNESS (METRES) FROM SOBANSKI
Upper Ordovician	Russell Queenston	Predominantly shales 7	30
	Carlsbad	Predominantly shales 6	70
	Billings Eastview Lindsay Disconformity	Shales and limestones 5	100
Middle Ordovician	Verulam Bobcaygon Gull River Disconformity	Limestones	230
	St. Martin Rockcliffe Disconformity	Limestones, shale 4	60
Lower Ordovician	Oxford March	Dolostone 3	110
Upper Cambrian	Nepean Unconformity	Sandstone 2	260
Precambrian		Igneous and Metamorphic rocks 1	

Note: **Number refers to the aquifer sequence on Figure 4a.**

TABLE 2

- HEALTH-RELATED BACTERIOLOGICAL PARAMETERS

Parameter	MOE Objective*	Comments
Fecal coliforms	0	Pathogens and indicators of fecal contamination
Fecal streptococci	0	
Total coliforms	<5	Indicators of possible or potential contamination

* The MOE Objectives are expressed as the plate count per 100 ml of sample.

* The above objectives are for water considered SAFE for drinking

- HEALTH-RELATED CHEMICAL PARAMETERS

Parameter *	MOE Objective	Comments
Sodium (Na)	-	levels may be of interest to authorities who wish to prescribe low sodium diets for their patients
Fluoride (F)	2.4 mg/l	excesses may cause fluorosis
Nitrate (NO3)	10.0 mg/l	contamination indicator; excess dangerous to infants
Nitrite (NO2)	1.0 mg/l	contamination indicator
Turbidity **	1 F.T.U.	could indicate problems in well construction or a naturally occurring problem

* other parameters may be added when appropriate

** test parameters must be reported in proper units. If units of measure do not match the units presented above, conversion ratios should be provided.

TABLE 2 cont.

COMMONLY OCCURRING AESTHETIC CHEMICAL PARAMETERS AND POLLUTION INDICATORS

Parameter *	Comments For Symptoms	Maximum Desirable Concentration (1)	Maximum Concentration Considered Reasonably Treatable (2)	Comments on Treatment
Chloride	Associated with salt problems	250 mg/l	Compliance	**
Colour	-	5 T.C.U. (True Colour Units)	7 T.C.U.	On the basis of a Carbon Filter Treatment System Capability
Iron	Excesses cause staining of plumbing fixtures and laundry	0.3 mg/l	up to 5.0 mg/l	By Water Softeners or Manganese Greensand Filters
			> 5.0 mg/l to 10.0 mg/l	Air Oxidation with filtration through proprietary filter media or Chlorination followed by sand or multi-media filtration
Manganese	Excesses cause staining of plumbing fixtures and laundry	0.05 mg/l	1.0 mg/l	By Water Softeners or Manganese Greensand Filters
Methane	-	3.0 l/m3	Compliance	**
Phenol	-	0.002 mg/l	0.05 mg/l	Chlorination and Post Carbon Filtration
Sulphate	-	500 mg/l	Compliance	**
Sulphide	Determine on fresh sample	0.05 mg/l as H_2S (inoffensive) (1A)	1.0 mg/l	By Chlorination (up to 0.3 mg/l) or Manganese Greensand Filters or Proprietary Media Filters
Tastes & Odour	Site specific,	inoffensive	-	-
T.D.S. Total Dissolved Solids	Considered an indicator of possible problems with dissolved components	500 mg/l	-	Requires written assurance (with rationale)that problems associated with taste, solids, precipitation or corrosivity will not occur

mg/l=milligrams per litre, l/m3=litres per cubic metre

TABLE 2 cont.

COMMONLY OCCURRING AESTHETIC CHEMICAL PARAMETERS AND POLLUTION INDICATORS (CONTINUED)

Parameter *	Comments For Symptoms	Maximum Desirable Concentration (1)	Maximum Concentration Considered Reasonably Treatable (2)	Comments on Treatment
Conductivity	-	M.D.C. for TDS= 500 mg/l 0.65(+0.10)x Conductivity = TDS limit	-	-
Ammonia	Contamination indicator	-	-	-
Background Bacteria	Contamination indicator	-	-	-
Tannins	Contamination indicator	-	-	-
T.O.C. Total Organic Carbon	-	5.0 mg/l as C	10.0 mg/l as C	By Carbon Filter
pH	6.5-8.5 desirable range	-	-	-
Calcium	Associated with mineral Scaling problems	-	-	-
Magnesium	Associated with mineral scaling problems	-	-	-
Alkalinity	Associated with mineral scaling problems	-	-	-
Hardness	< 200 mg/l desirable, taste	-	-	-

mg/l=milligrams per litre

* Other parameters may be added when appropriate or at the discretion of the consultant

** Compliance with drinking water objectives since an economically feasible water treatment system does not exist

NOTE: References

(1) - Ontario Drinking Water Objectives (Green Book, Revised 1983 ISBN 0-7743-895-0)

(1A) - Guidelines For Canadian Drinking Water Quality (1987 Health and Welfare Canada, ISBN 0-66012644-3)

(2) - Reasonable for Whole House Water Supply, no unusual space or backwash requirement and system must be in relatively common, widespread use (Provided by Water Resources Branch of the Ministry of the Environment)

NOTE: Treatment systems requiring backwash facilities will be considered on the basis of proven well yield capabilities of 17 litres per minute or greater

Parameter							
MOE Subdivision List	MOE	Notes	EEC	Notes	USEPA	WHO	Notes

HEALTH RELATED PARAMETERS	**MAC**		**MAC**		**MAC**	**GV**	
Bacteriological							
Plate Count per,100 ml							
Total coliforms	<5		<1		1	10	
INORGANIC PARAMETERS							
Sodium (mg/l)		20 mg/l health advisory		20 mg/l health advisory		200	taste consideration
Fluoride (mg/l)	2.4		1.5		1.4-2.4	1.5	guideline
Nitrate (mg/l)	10	expressed as N	50	expressed as Nitrate	10	10	
Nitrite (mg/l)	1	expressed as N	0.1	expressed as Nitrite	1	1	
Turbidity (NTU)	1		10 mg/l Silicate		1-5	5	less 1 with disinfection
AESTHETIC PARAMETERS	**MDC**	**MCCRT**	**GL**		**2ND MCL**	**GV**	
Total Dissolved Solids (mg/l)	500	excess needs written assurance	400	in S/cm	500	500-1500	
Ammonia(mg/l)		contamination indicator	0.5				
Background Bacteria(p.co. 100ml)		contamination indicator	10 @ 37C	100 @ 22C			
Tannins (mg/l)		contamination indicator					
Total Organic Carbon(mg/l)	5	up to 10 treatable		any increase has to be investigated			investigate changes in levels
pH	6.5-8.5		9.5		6.5-8.5	6.5-8.5	
Calcium (mg/l)		Refer to table 2					
Magnesium (mg/l)		Refer to table 2	50				
Alkalinity (mg/l)		Refer to table 2	30	Minimum required			
Hardness (mg/l)		Refer to table 2	60	Minimum required		500	
Chloride (mg/l)	250				250	250	
Colour (TCU)	5	up to 7 treatable	20		15	15	
Iron(mg/l)	0.3	up to 10 treatable	0.2		0.3	0.3	
Manganese (mg/l)	0.5	up to 1 treatable	0.05		0.05	0.1	
Methane (l/m3)	3						
Phenol (mg/l)	0.002	up to 0.05 treatable	0.005			0.001	For chlorinated waters
Sulphate (mg/l)	500		250		250	400	
Sulphide (mg/l)	0.05	up to 1.0 treatable	No odour		non detectable	non detectable	
Taste	inoffensive		2 @ 12C 3 @ 25C	Dilution #		non offensive	
Odour	inoffensive		same as taste		3	non offensive	

References: Canadian Council of Resource and Environment Ministers, 1987. Canadian Water Quality Guidelines. Environment Canada

Carney, M., 1991 European Drinking Water Guidelines. J AWWA 1991

MOE, 1991. Guideline Water Supply for New Subdivision Development on Private Services. Ministry of the Environment South Eastern Region

Sayre, I. M. , 1987 International Standards for Drinking Water. J. AWWA

USEPA, 1990. Fact Sheet, Drinking Water Regulations Under the Safe Drinking Water Act. USEPA Criteria and Standards Division Office of Drinking Water

WHO, 1984. Guidelines for Drinking Water Quality Volume 1 Recommendations. World Health Organization

TABLE 3

Existing Water Quality Guidelines

GEO-ANALYSIS

Project No. G9105

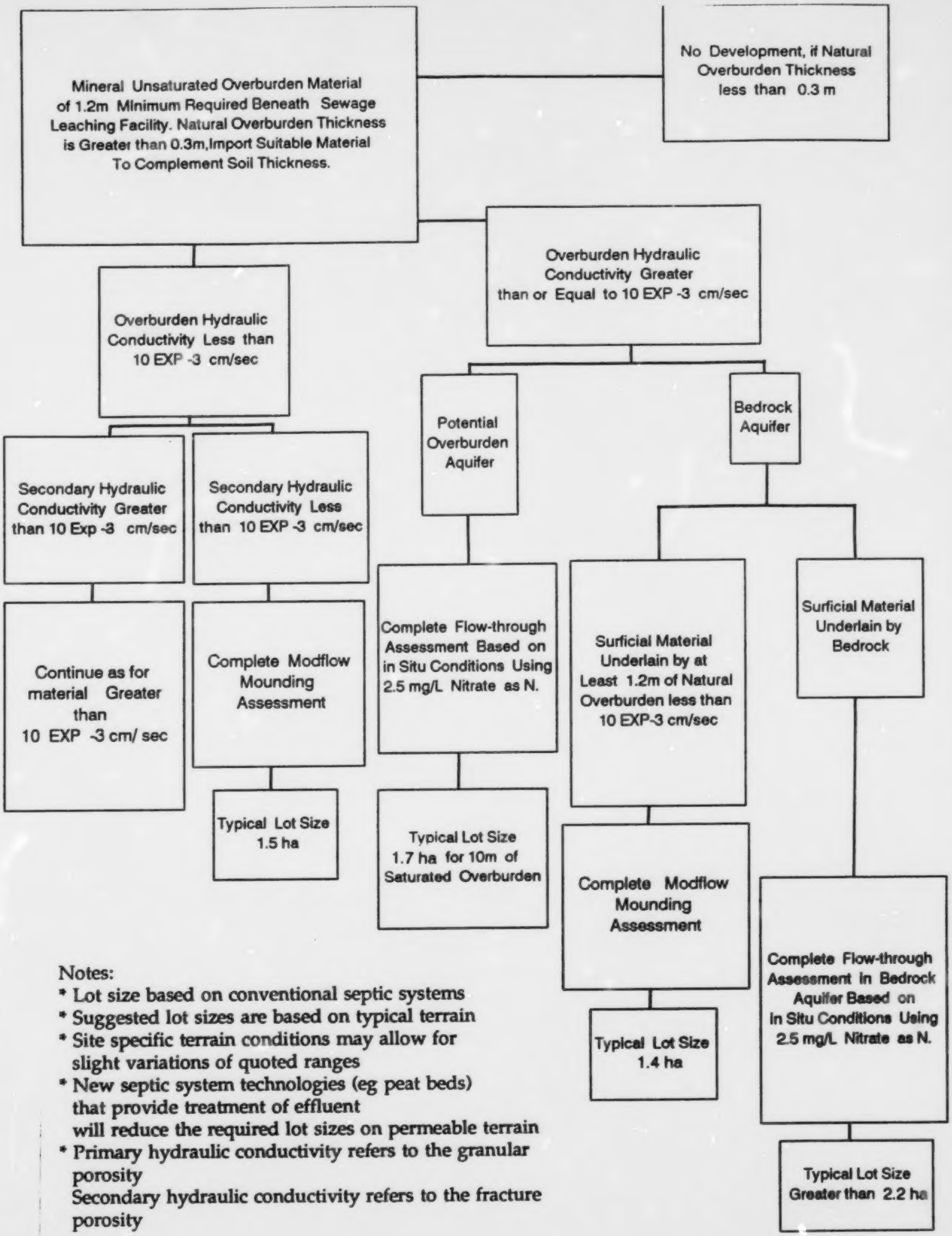
Regulatory Agency	Present MOE	Proposed MOE	US EPA	Remarks
Typical Requirement				
Minimum Soil Depth	0.25m	0.25m	0.6m to 1.2m	A total of 22 states
			Most States in excess of 1.2m	which include the
Type of Systems	Mound System	Mound System	Mound System, Artificially Drained System,	Northeastern States have a
			Peat System, Aerobic-Anaerobic Treatment	minimum requirement of
Engineered Upgrading	Raised Bed	Raised Bed	Imported Fill, Watertable Adjustments	unsaturated soil thickness
				of 1.2m
Impact Assessment	None	Yes, Also Spare Area	None, Some States Spare Area	
Density	None	1Ha	None	
Flow Rate	Based on Proposed Use	3000L/day	Based on Proposed Development	

TABLE 4

Septic System Policies

GEO ANALYSIS

Project No. G9105


Mineral Unsaturated Overburden Material of 1.2m Minimum Required Beneath Sewage Leaching Facility. Natural Overburden Thickness is Greater than 0.3m, Import Suitable Material To Complement Soil Thickness.
No Development, if Natural Overburden Thickness less than 0.3 m
Overburden Hydraulic Conductivity Less than 10 EXP -3 cm/sec
Overburden Hydraulic Conductivity Greater than or Equal to 10 EXP -3 cm/sec
Secondary Hydraulic Conductivity Greater than 10 Exp -3 cm/sec
Secondary Hydraulic Conductivity Less than 10 EXP -3 cm/sec
Potential Overburden Aquifer
Bedrock Aquifer
Continue as for material Greater than 10 EXP -3 cm/ sec
Complete Modflow Mounding Assessment
Complete Flow-through Assessment Based on in Situ Conditions Using 2.5 mg/L Nitrate as N.
Surficial Material Underlain by at Least 1.2m of Natural Overburden less than 10 EXP-3 cm/sec
Surficial Material Underlain by Bedrock
Typical Lot Size 1.5 ha
Typical Lot Size 1.7 ha for 10m of Saturated Overburden
Complete Modflow Mounding Assessment
Complete Flow-through Assessment in Bedrock Aquifer Based on In Situ Conditions Using 2.5 mg/L Nitrate as N.
Typical Lot Size 1.4 ha
Typical Lot Size Greater than 2.2 ha

Notes:
- * Lot size based on conventional septic systems
- * Suggested lot sizes are based on typical terrain
- * Site specific terrain conditions may allow for slight variations of quoted ranges
- * New septic system technologies (eg peat beds) that provide treatment of effluent will reduce the required lot sizes on permeable terrain
- * Primary hydraulic conductivity refers to the granular porosity
  Secondary hydraulic conductivity refers to the fracture porosity

TABLE 5

Lot Size Determination Based on Private Individual Services

GEO ANALYSIS

Project No. G9105

APPENDIX A

[illegible]

Planning Department
Tel. (613) 560-2053
Fax (613) 560-6006

Service de l'urbanisme
Tél. (613) 560 2053
Télécopieur (613) 560-6006

Nov 09, 1990

File: 28.500

Jacques Sauriol
Geo-Analysis
Box 13010
Kanata, Ontario
K2K 1X3

Dear Mr. Sauriol:

Re: Private Individual Services in Rural Area

Attached is a Request for Proposals to undertake a study on private services in the rural area. The text is self-explanatory.

If you are interested in submitting a proposal for this work, I would like to emphasize that you should cost out each aspect of the work. Due to budget limitations, we may have to have the work done in parts.

Also, the Ministry of Municipal Affairs would like us to extend the project to include the Townships around Ottawa-Carleton (see attached map). This would affect the cost of some of the work and we would appreciate knowing what the additional cost would be.

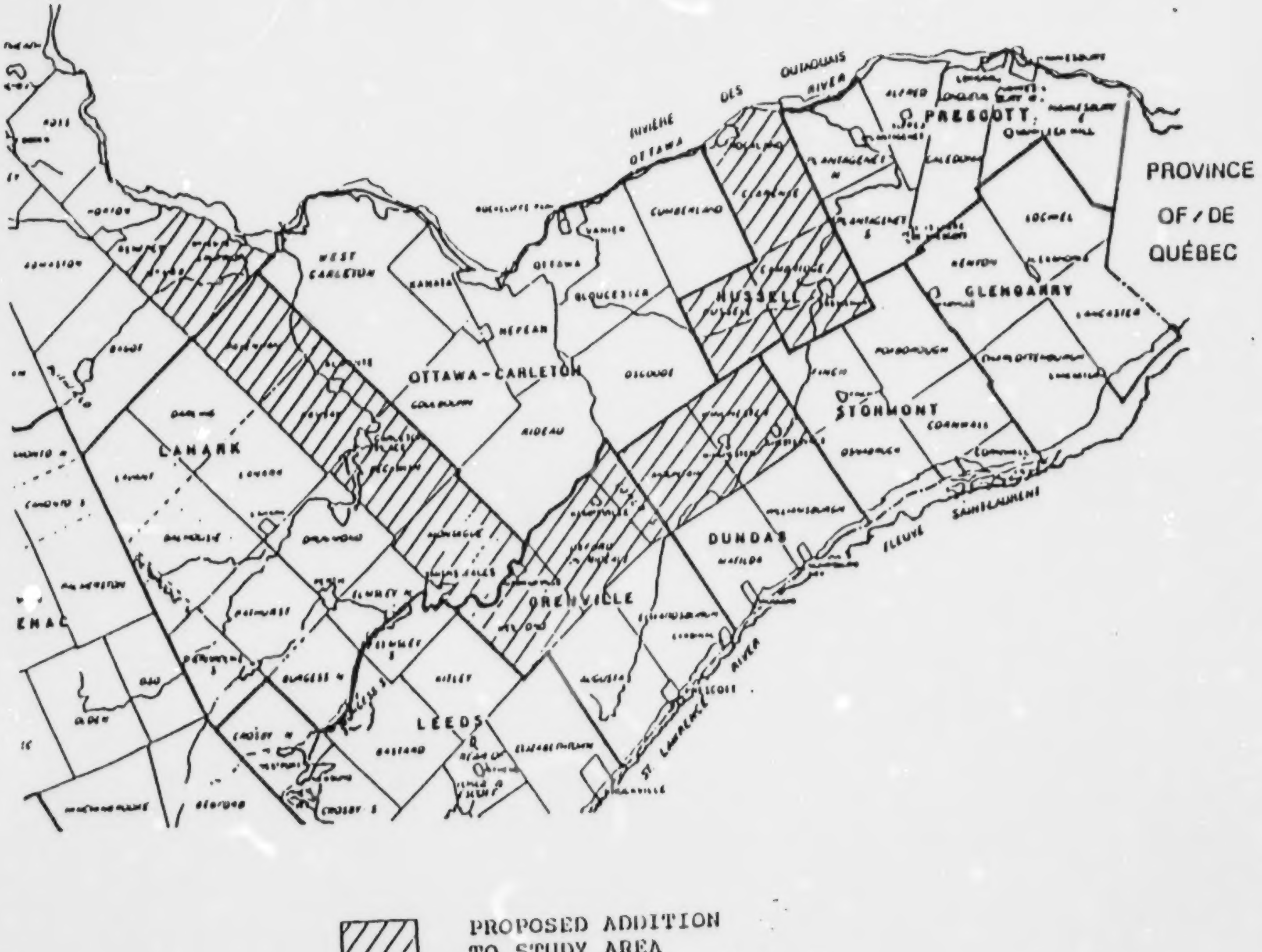
If you have any questions, do not hesitate to call.

Yours truly,

L. Paterson

Lesley Paterson
Policy and Programs Division

Attach:


PROVINCE
OF / DE
QUÉBEC
RIVIÈRE DES OUTAOUAIS
OTTAWA RIVER
PRESCOTT
GLENGARRY
RUSSELL
STORMONT
DUNDAS
OTTAWA-CARLETON
WEST CARLETON
LANARK
GRENVILLE
LEEDS
FLEUVE SAINT-LAURENT
ST. LAWRENCE RIVER
▨ PROPOSED ADDITION TO STUDY AREA

REQUEST FOR PROPOSALS

PRIVATE INDIVIDUAL SERVICES IN THE RURAL AREA

BACKGROUND

Regional Council approved funds in the 1990 budget of the Planning Department, to do a study on the impact of rural development. Various regional government departments and area municipalities were contacted to get input into determining the main issues. In general, there is a need to more clearly define the criteria for establishing the location and amount of rural development. The cost of rural development and the ability to deliver services are important issues. However, the most critical, and least well explored issue, is the definition of appropriate requirements for the approval of rural development on private individual services.

It is expected that the findings of this study will provide direction in determining where rural development can occur and how much can be accommodated. There has been little research into the cumulative effect of development on private services in Ottawa-Carleton. In addition, there is interest in exploring means to ensure that the regulatory mechanisms will contribute to maintenance of the groundwater resource and provision of a safe and reliable source of water.

INTRODUCTION

a) Regional Policy

Section 4.0 of the Regional Official Plan states: "Development in the rural area will be primarily on the basis of private individual services. It is recognized that the continued safe operation of private individual services may place limits on the amount, distribution and type of development which may take place, but this is seen as beneficial in maintaining a rural area distinct from the urban area". The policies require rural development to be on the basis of private individual services unless:

1. services are permitted by Schedule H of the Regional Official Plan; or
2. a public health problem arises and Council determines that communal services are the best solution; or
3. the development meets the specific requirements for multiple unit development.

A review of Section 4, Development in the Rural Area and Section 10.1.2, Policies for Water Supply and Sewage Treatment will provide Regional Council's policies in this area. In addition to the policies in the Regional Official Plan, Council has approved a detailed terms of reference for village wide servicing studies required to support village expansion on private services.

b) Emerging Issues

A number of municipalities have applied for, or are in the process of applying for, extensions of regional systems to villages where the water quality is poor. Presumably, the requirements for a village wide servicing study to support expansion of a village, will reduce the likelihood of similar problems emerging in the future. However, some villages may have reached a critical point and a problem may be imminent.

There are concerns related to country lot development as well. Recently, subdivisions have been approved with poor water quality, subject to in-home treatment facilities. Problems may occur at a later date if the system fails. Also, certain studies are required to support a development but no agency oversees the installation of private individual services.

Another important aspect is the long term reliability and impact of individual sewage disposal systems. The issue of drinking water cannot be separated from sub-surface sewage disposal.

The regional official plan directs that country lot development should avoid aquifer recharge areas. However, these areas have not been formally identified.

Finally, the cumulative impact on groundwater quality/quantity of rural development is not being addressed.

PURPOSE OF STUDY

The purpose of this study is to recommend policies and practices that should be implemented to ensure safe and appropriate rural development on private, individual services. In addition, there is a requirement to put together the available information in Ottawa-Carleton that can help to guide rural development to take place in appropriate locations and numbers (in regard to servicing issues). The consultant should address the implementation process, but is not confined to those aspects that can be addressed by Regional policy. It would be useful to provide information in map form wherever possible.

ELEMENTS OF STUDY

The questions posed here should be addressed in consultation with the Ministry of the Environment. Also, it is not intended that this work duplicate the work that has been done or is ongoing in any area municipality.

1. Water Quality Standards - the Ontario Water Resources Act does not apply to private systems and the Drinking Water Objectives were not developed for private systems. However, municipalities generally rely on the Ministry of the Environment to review and advise on private systems and to apply those objectives. Since the practice is to permit some treatment to achieve the aesthetic standards there is growing concern that municipalities are going to be faced with homeowner complaints about poor water in the future.

   i) Should the Ontario Drinking Water Objectives apply equally to private individual systems and to communal systems?

   ii) Since MOE is not responsible for approving private individual systems under the OWRA, should the RMOC consider assuming this responsibility and develop standards? Should its policies on water quality be more specific?

   iii) Should the OWRA apply to private individual systems?

   iv) How much treatment is considered reasonable for a homeowner from a cost and maintenance point of view?

   v) Are there any aesthetic parameters, in the Ontario Drinking Water Objectives, that can be health problems at certain concentrations?

   vi) What is the total list of health parameters that should be reviewed in the approval of private services?

   vii) Should there be different requirements for some types of development? Should they be on communal systems? services?

2. Well Construction

   i) What requirements does each area municipality in the RMOC apply to well drillers and well drilling. Which are most effective in ensuring appropriate well construction for its safe, long term operation?

   ii) Some municipalities in Ontario have well inspectors. What do they do? Should the area municipalities, or the RMOC, have such a person?

iii) Current regulations for well construction specify minimum standards. How does a municipality ensure that site specific requirements, that may exceed the minimum prescribed by regulations, are clearly defined?

3. Aquifer Recharge Areas

i) Identify major aquifer recharge areas in Ottawa-Carleton and enunciate appropriate policies to guide land uses in these areas. This is essentially a request for aquifer management plans to look at their sensitivity, capability and any impacts/threats.

4. Water Quality in Ottawa-Carleton

i) Using all available studies prepared over the years for development in Ottawa-Carleton, well water records and any other material available for this Region, identify locations where water quality is poor or likely to be poor. Indicate whether development on private services should be restricted in these areas or what other action might be appropriate.

5. Sewage Disposal Systems

The MOE implemented policy 15-08 "Incorporation of the reasonable use concept into MOE groundwater management activities" on April 15, 1986. The reasonable use policy requires that an on-site sub-surface sewage disposal system does not impact negatively on the water quality of the adjacent property.

The cumulative effect of large Country Lot Subdivisions and Village Expansions serviced with septic tank systems of aerobic "Class 6" system, could in certain circumstances affect ground water quality. This would in turn affect water supply from individual wells. The reasonable use policy would require a hydrogeological study dealing with the groundwater flow of contaminant (leachate from individual sewage disposal system must be dispersed sufficiently so that the contaminant levels are within the Ontario Drinking Water Objectives).

i) In consultation with the Ministry of the Environment, identify when and/or where the requirements of the reasonable use policy apply to Village Expansions and Subdivisions of more than five private residences with individual sub-surface sewage system.

ii) Should detailed Terms of Reference for hydrogeological study be developed in order to demonstrate that any Country Lot Subdivisions of more than five units will not impinge on the ground water quality?

6. Distribution and Cumulative Impact of Rural Development

i) Are there any guidelines to assist in evaluating the maximum size of a country lot subdivision, or series of contiguous subdivisions, from a private, individual services point of view? (the Regional Official Plan currently requires phasing of a subdivision exceeding 40 lots. Is this appropriate?)

ii) Is there a way to determine an appropriate minimum lot size to accommodate private individual services? (ie. if servicing was the only criterion).

iii) Is it possible to identify the carrying capacity of different parts of the rural area for rural development on private services? This is to address the cumulative impact in abundance to provide a framework for considering development proposals.

PROPOSAL

The consultant is required to develop a study proposal that will respond to the questions and issues raised in this document. The proposal should be of sufficient detail to identify methodology and level of effort for each element. The consultant is not confined to the points raised here but, based on personal knowledge and experience, could enhance the range of items to be addressed, if appropriate.

Level of effort should be expressed in time and cost for each element to allow a valid comparison of proposals.

All persons expected to work on the study should be identified in addition to their share of the work and any relevant experience.

Two copies of each proposal should be submitted to:

Lesley Paterson
Manager, Planning Policy
Planning Department
111 Lisgar Street (Cartier Square)
2nd Floor
Ottawa, Ontario
K2P 2L7

Tel: (613) 560-2053
Fax: (613) 560-6006

by 4:30 p.m. December 03, 1990

APPENDIX B
WELL COMPLIANCE PROGRAM

WELL COMPLIANCE PROGRAM		
TOWNSHIP	ANSWERED	WELL COMPLIANCE PROGRAM
Oxford-On-Rideau	no	yes*
Wolford	no	no*
Winchester	no	no*
South Gower	no	no*
Mountain	no	no*
Beckwith	yes	no
Montague	yes	no
Pakenham	yes	no
Cambridge	yes	no
Russell	no	no*
Gloucester	yes	no
Kanata	yes	no
Nepean	yes	no
Cumberland	yes	yes
Goulbourn	yes	yes
Osgoode	yes	yes
Rideau	yes	yes
West Carleton	yes	no
McNab	yes	no
Clarence	no	yes*
Ramsay	yes	no

* Although these municipalities did not specifically respond in writing to the request for this information it is understood that this is their present status with regards to a well compliance program.

APPENDIX C

Ontario
Ministry
of the
Environment
Ministère
de
l'Environnement

Central
Region
Région du
Centre

7 Overlea Boulevard
4th Floor
Toronto, Ontario
M4H 1A8
416/424-3000
Fax: 416/963-2935

7, boulevard Overlea
4e étage
Toronto (Ontario)
M4H 1A8
416/424-3000
Fax: 416/963-2935

1991 08 06

Received
Sep 23 91

[illegible] 3 1991
RECEIVED
INITIAL
FILE NO.

Dear Sir/Madam:

Re: **Central Region's Interim Guidelines for Preparing Hydrogeological Studies for Land Development Proposals Based on Individual Wells and/or On-Site Subsurface Sewage Systems**
Our Files: EP-03-01 & GW-07-01

Central Region has revised its approach to the assessment of development applications based on wells and/or subsurface sewage disposal systems. These interim guidelines replace the guidelines released on June 30, 1989 and will be used until a Ministry policy has been approved. The Ministry's policy regarding multi-unit development on subsurface sewage disposal systems is currently under review. It is the Ministry's preference that such development be serviced by communal systems.

The attached documents set out our approach in reviewing land development proposals. It is hoped that these guidelines will provide clear direction for the preparation of complete hydrogeology studies, thereby reducing time required for review and approval. Please note that a screening process is in place to determine whether sufficient information is provided in studies to warrant a full review by staff. Incomplete studies will be returned for revision, prior to a full review. It is therefore in the best interest of all concerned that these studies be completed as set out in the guidelines.

The overall thrust of these guidelines is to ensure that development sites have sufficient capacity to support the proposed development; and that the environment, those who use the development and neighbouring uses will not be adversely affected.

We welcome input from you in the form of suggestions for improvement of our procedures. If you have any comments on this package, please forward them in writing to the address at the top of this letter.

Yours truly,

Jim Merritt
Regional Director

hz:rr.let

CENTRAL REGION
INTERIM GUIDELINES
FOR PREPARING HYDROGEOLOGICAL STUDIES FOR LAND DEVELOPMENT PROPOSALS BASED ON INDIVIDUAL WELLS AND/OR ON-SITE SUBSURFACE SEWAGE SYSTEMS

EFFECTIVE AUGUST 6, 1991

INTRODUCTION

While Ministry policy is being developed, Central Region is following these interim guidelines, as set out below, which are aimed at preventing groundwater nitrate contamination in excess of current standards. These guidelines are a revision of the information requirements outlined in "Central Region Procedures for Assessing Subdivision Development Proposals where Subsurface Sewage Disposal is Contemplated", dated June 30, 1989. These guidelines may be replaced at any time by a Ministry of the Environment policy governing development on individual private subsurface sewage systems.

The sewage discharged to the groundwater system by subsurface sewage disposal systems has the potential to contain any of a very long list of contaminants. Nitrates, or compounds convertible to nitrates, are included. Because of the difficulty in attempting to evaluate the potential groundwater impacts of each and every contaminant, and due to the persistent hydrogeochemical characteristics of nitrates in groundwater, nitrates have been chosen as the critical contaminant to be considered in the evaluation of the inputs to groundwater predicted from land development proposals.

Nitrates are identified in the Ontario Drinking Water Objectives as a health-related parameter. In this respect, the maximum allowable nitrate concentration in drinking water is set at 10 mg/L as N.

The purpose of the guidelines is to ensure that hydrogeological studies are undertaken in a complete and consistent manner. This approach should result in minimization of potential adverse impacts on groundwater and surface water, and on the people who live, work or play on the development site and on surrounding lands.

In this regard, a detailed hydrogeology study must be submitted in support of approval of plans of subdivision, plans of condominium and some official plan amendments. The study submitted should deal with all hydrogeological issues (i.e.; physical setting, water supply and development impact). When revisions are required to this study as a result of Ministry of the Environment review, the entire study should be resubmitted with all changes clearly flagged. The study should also contain a clearly stated set of conclusions and set of

recommendations for all hydrogeological components. The study must determine whether an adequate supply of potable groundwater is available, and it must evaluate the impact of sewage system effluent on the groundwater resource. The study will be required by Central Region prior to recommendation of draft approval of plans of subdivision and condominium, and prior to approval of some official plan amendments.

The hydrogeological study should be submitted as part of the package of planning documents circulated for review by the Ministry of Municipal Affairs or by a municipality that has been delegated with circulation and approval authority under the Planning Act. Preparation and inclusion of hydrogeology studies with planning documents should assist greatly in establishing the water and sewage servicing principles for the development, and in establishing appropriate densities. One of the benefits will be a reduction in delays. For planning proposals other than those previously noted (i.e., Official Plans, Secondary Plans and other Official Plan Amendments), Central Region recommends that comprehensive, large scale assessment of groundwater and surface water be undertaken which includes but is not limited to potential development and servicing alternatives. This recommendation is made in recognition of the value of large scale assessments to planning in general, and in particular, to the input of information at the earliest possible time in the process.

Hydrogeological reports must include (but may not necessarily be restricted to) the following information:

I. PHYSICAL SETTING

- Provide regional and local maps which show site location with Lot and Concession Numbers. Use topographic maps of 1:10,000, 1:25,000 or 1:50,000 scale, from Ontario Base Mapping or National Topographic Series. Use maps of the scales that best describe the site and that best show its location.

- Describe topography and surface drainage conditions, as well as adjacent wetlands, watercourses and flood plains within at least 500 metres of the site. Make use of maps to clearly describe these features.

- Identify surrounding land uses and types of servicing, and identify on-site land use. Use maps to depict this information.

- Identify any groundwater contamination sources, aquifers of known concern and water use conflicts in the area.
- Identify and provide references to any approved (by MOE) studies/reports available for the area.

II. WATER SUPPLY

Requirements itemized below apply to individual domestic wells but not to communal wells or water takings in excess of 50,000 L/day where a Permit to Take Water is required. (Separate guidelines apply to communal wells. The attached checklist contains information required in Permit to Take Water submissions for communal wells.)

- Describe regional and local overburden and bedrock geology.
- Tabulate MOE well record data. Well record printout information must be supplemented by a table containing the most recent well record information and any information from unrecorded wells found during the field survey.
- Identify all pre-existing on-site wells. Make recommendations for abandoning them properly (Ontario Regulation 612/84) where required. Include any wells for which there are no MOE well records, in addition to those for which there are MOE well records.
- All on-site test wells and all on- and off-site wells identified through MOE records and through surveys must be plotted on a map. Maps of 1:10,000 scale are preferred.
- Determine whether the on-site aquifer(s) can meet the water demand from the proposed development. Provide an estimate of site-specific and regional recharge based on water budget, geology, soils and hydrogeology.
- Drill on-site test well(s). The number of wells is dependent on the heterogeneity of the subsurface stratigraphy and on the size of the property.

- Perform pump-tests on the on-site test well(s). The pump tests must be a minimum of 6 hours duration, or longer where conditions require it. Determine the adequacy of well-water supply. Water supply must be a minimum of 2700 L/day/lot. Provide water storage recommendations where necessary.

- Provide test well logs with complete stratigraphic information.

- Prepare hydrostratigraphic cross-sections. Identify preferred aquifer for water supply.

- Identify any communal, municipal or high-yield individual wells and their potential to interfere with on-site wells.

- Analyze water samples from on-site test wells to determine the acceptability of water quality. Base the determination on the health-related parameters (must include microbiological parameters) and the aesthetic-related parameters of the Ontario Drinking Water Objectives.

- Provide water treatment recommendations, where necessary.

III. DEVELOPMENT IMPACT

The Ministry of the Environment has delegated the responsibility for administration of Part VII of the Environmental Protection Act (sewage systems programme) to either the local Health Unit or other designated agency. Therefore, these guidelines regarding subsurface sewage disposal systems should be viewed as complementary to those of the agency responsible for Part VII. In addition, as the hydrogeological study may only be part of the total soils/site assessment requirements regarding sewage disposal, the proponent and his consultant are cautioned against proceeding with the hydrogeological study without first having input from the agency responsible for Part VII. The proponent should discuss sewage system flows with the local Part VII Director of the Ontario Environmental Protection Act.

Nitrate is the critical contaminant for determining the impact of sewage system effluent on groundwater quality. There is no practical way to determine how sewage system effluent mixes with groundwater, and consequently, the resulting nitrate concentration cannot be easily predicted. Therefore, the following guidelines describe a straightforward model for estimating nitrate impact. The model considers only four parameters: the mass of nitrate in the sewage system effluent; background nitrate concentration; the volume of on-site infiltration recharge; and the resulting nitrate concentration at the property boundary. The model assumes complete mixing between the nitrate mass and all of the on-site infiltration. For the purpose of calculating the resulting nitrate concentration, the model ignores the volume of sewage system effluent. **Use of water from municipal or deep aquifer sources for nitrate dilution is not acceptable.**

- Determine on-site background nitrate concentration in the upper aquifer. If the concentration is 10 mg/L as N (as nitrogen) (Ontario Drinking Water Objectives) or greater, then the site cannot be developed, even if municipal water is provided. Where background concentration of nitrate as nitrogen is greater than 0 mg/L, but less than 10 mg/L, the background concentration must be taken into consideration in determining the amount of development impact permitted. This means that if background concentration exceeds 0 mg/L, then development impact will be restricted to the difference between the background concentration and the Ontario Drinking Water Objective of 10 mg/L. Density of development must therefore be based on this level of impact. Expressed in another way, background concentration plus concentration from development impact must not exceed 10 mg/L at the property boundary.

- Provide an estimate of site-specific infiltration recharge. The estimate should be based on a water budget, soil type(s), surface geology and impermeable areas proposed for the site (i.e.; roads, driveways, rooves, parking lots, etc.). Data from basin studies should be used where they are available. Determination of soil type and surface geology must include grain-size analyses on samples from test pits and/or boreholes, and sample collection for this purpose should be done at a frequency of at least 1 sample/2.5 ha.

- For residential and industrial/commercial development, to calculate the diluted nitrate concentration at the property boundary, use infiltration recharge water only. **Do not use the volume of sewage system effluent.**

- For residential development, assume 1000 L/day/lot of sewage system effluent with a nitrate concentration of 40 mg/L as N.

- For all development on subsurface sewage systems with an effluent flow less than or equal to 4500 L/day, nitrate concentration at the property boundary must not exceed 10 mg/L as N (Ontario Drinking Water Objectives).

- For industrial/commercial development, assume that the sewage system effluent has a nitrate concentration of 40 mg/L as N. The sewage will consist of domestic wastes only. No commercial or industrial process wastewater is permitted. To predict the sewage system flows from industrial/commercial developments, refer to the MOE Manual of Policy, Procedures and Guidelines for Onsite Sewage Systems (Appendices 9.3.1 and 9.3.2).

- For all development on subsurface sewage systems with an effluent flow greater than 4500 L/day for a particular lot, block or other parcel of land, nitrate concentration at the boundary of that lot or block must meet MOE Policy 15-08 and MOE Notice 3/87.

- For industrial/commercial development, to determine the maximum allowable sewage system effluent flow for each lot or block of a site, first determine the maximum allowable sewage system effluent flow for the entire proposal site, and then allocate to each lot/block its share of the maximum site flow (based on the ratio of the lot/block area to the site area).

- If a surface water body forms the downgradient boundary of the proposed development, then the proponent must submit a study (prepared by an individual with suitable expertise) that assesses the potential impact of the sewage system effluent on the water quality of the receiving surface water body. The study must include all parameters of concern in accordance with policies and Provincial Water Quality Objectives outlined in the Blue Book "Water Management: Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment". The study must assume the "worst case" scenario that all effluent from the subsurface sewage system(s) enters the surface water body without attenuation by soil and with dilution by on-site infiltration recharge only.

Ontario
Ministry of the Environment
Ministère de l'Environnement

Central Region
Région du Centre

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Fax: 416/963-2935

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1991 08 01

*

Dear *:

Re: *
*
Our File: *
Hydrogeology Study *
4:1 Checklist Review

To facilitate the review of hydrogeological studies submitted in conjunction with development proposals, an initial screening exercise has been implemented in Central Region. This exercise involves a systematic examination of the study to verify that sufficient information has been provided for the technical review. Incomplete studies are being returned to applicants in order that resubmission of complete studies may be expedited.

An examination of the above noted study has shown required information is lacking, as outlined in the attached checklist. The study should be appropriately modified to reflect these concerns and then be resubmitted for technical review. The entire study should be resubmitted with all changes clearly flagged. If the study is still incomplete, it will be returned again for modification, without complete review comments.

Please note that the attached checklist is not meant to be an all-inclusive or exhaustive list of considerations to be contained in a hydrogeology study. The onus is on the consultant to ensure that a complete and thorough hydrogeological study is undertaken on behalf of the proponent.

Thank you for helping to avoid unnecessary delays that result from submission of incomplete studies.

*

cc: *
EQA Unit
A & P File

Attachment

POS.17

SCREENING CHECKLIST FOR HYDROGEOLOGY STUDIES SUBMITTED IN SUPPORT OF LAND DEVELOPMENT PROPOSALS IN ACCORDANCE WITH THE AUGUST 6, 1991 INTERIM HYDROGEOLOGY GUIDELINES

File number: **Municipality:**

	Yes	No	N/A
I. WATER SUPPLY			
(a). Were enough test well(s) drilled on-site?	___	___	___
- were pump-test(s) of minimum 6 hours duration conducted?	___	___	___
- were water quality analyses for O.D.W.O. health- and aesthetic-related parameters conducted on samples from the test wells?	___	___	___
(b). Has well interference potential been addressed?	___	___	___
II. DEVELOPMENT IMPACT			
(a). Has the on-site background nitrate concentration been proven to be less than 10 mg/L as N?	___	___	___
(b). Were enough test pits dug on-site?	___	___	___
(c). Are enough grain-size analyses curves for test pit samples included in the report?	___	___	___
(d). Is sufficient water budget information included?	___	___	___
(e). Is the estimated infiltration rate acceptable?	___	___	___
(f). Are nitrate-loading calculations included in the report?	___	___	___
(g). Is dilution through infiltration only?	___	___	___
(h). Is the nitrate-loading assessment acceptable?	___	___	___
(i). If the proposal is adjacent to a lake or river, has a surface water impact assessment been submitted? -	___	___	___

SCREENING CHECKLIST FOR PERMIT TO TAKE WATER REPORTS

NAME OF APPLICANT :

COUNTY/REGION: TOWNSHIP :

CONCESSION : LOT :

	YES	NO	N/A
I. APPLICATION FORM			
(a) Is the form an up-to-date original ?	___	___	___
(b) Is the form signed by a director or someone with approved signing authority for the applicant organization ?	___	___	___
(c) Are the wells being applied for the only sources of water on the site ?	___	___	___
II. DESIGN BRIEF			
NOTE: Pits and Quarries are exempt from this section.			
(a) Was a design brief submitted ?	___	___	___
(b) Was a Preliminary Hydrogeological Report submitted ?	___	___	___
(c) Was a Hydrogeological Report / Construction Report submitted ?	___	___	___
(d) Is there a complete water quality analysis (both chemical and bacteriological)?		___	___
(e) Is the proposed amount of water to be taken as indicated on the permit the same as the amount stated in the Design Brief ?	___	___	___

August 6, 1991

MEMORANDUM

To: Robert Ryan

From: Rosa Stewart

Re: Infiltration Recharge Rates

The following are the maximum acceptable infiltration recharge rates for the various types of soils to be used in the screening of hydrogeological studies submitted in support of subdivision developments. These rates were determined through discussion amongst hydrogeological staff.

The estimated infiltration recharge rates are based on representative drainage basin studies carried out by the Ontario Water Resources Commission.

Soil Type	Infiltration Rate (cm/a)
dense clay (or clayey till)	5.0
clayey silt (or clayey silt till)	10.0
silt (or silty till)	12.5
sandy silt or silty sand till	15.0
sand	20.0
sand, gravel	25.0

Infiltration rates selected are at the discretion of the consultant. If higher infiltration recharge rates are used in the nitrate assessment of the hydrogeology studies, very detailed site specific investigations should be conducted to support estimated infiltration rate.

ENVIRONMENT
SERVICING
DEVELOPMENT

IMPACT EVALUATIONS FOR PRIVATE SERVICES

1986: POLICY 15-08

Incorporation of the
Reasonable Use Concept
into MOE Groundwater Management Activities

Technical Guideline by Working Group V

THE INCORPORATION OF THE REASONABLE USE CONCEPT INTO THE GROUNDWATER MANAGEMENT ACTIVITIES OF THE MINISTRY OF THE ENVIRONMENT

1978: MOE Publishes "Blue Book"

Water Management - Goals, Policies, Objectives
and Implementation Procedures of the
Ministry of the Environment

Defines Goal

TO PROTECT THE QUALITY OF
GROUNDWATER FOR THE GREATEST
NUMBER OF BENEFICIAL USES

ENVIRONMENT
SERVICING
DEVELOPMENT

IMPACT EVALUATIONS FOR PRIVATE SERVICES

1987: NOTICE 3/87

Defines

Large Subsurface Sewage Disposal Systems

Permits either the Part VII Director or the Regional Director to designate lands as subject to Policy 15-08

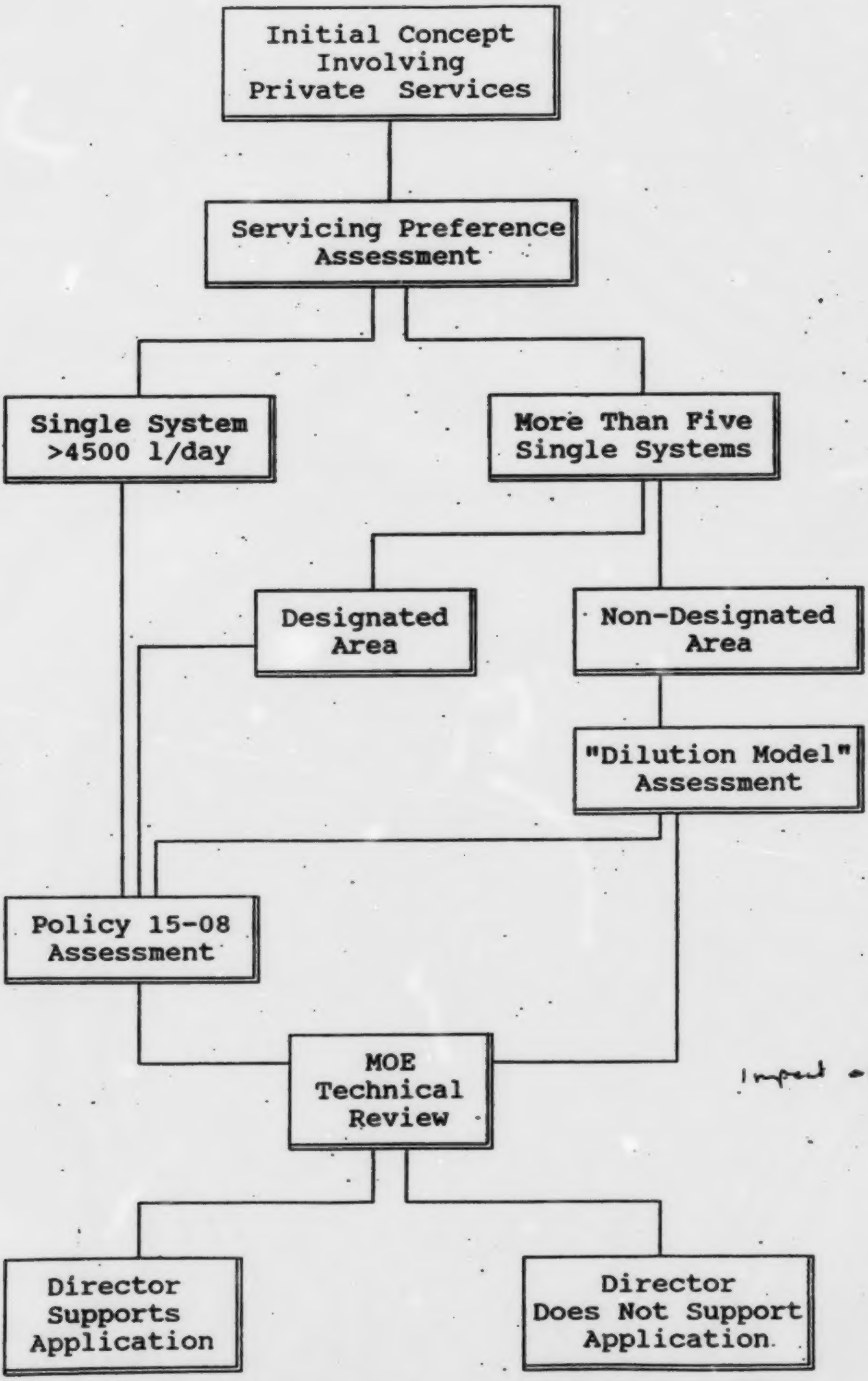
IMPACT EVALUATIONS FOR PRIVATE SERVICES

"DILUTION MODEL"

Intended to be used as a method to identify those sites which should be designated by the Director

Not intended to be used as a model for quantifying the expected nitrate impacts

IMPACT EVALUATIONS FOR PRIVATE SERVICES


Initial Concept Involving Private Services
Servicing Preference Assessment
Single System >4500 l/day
More Than Five Single Systems
Designated Area
Non-Designated Area
"Dilution Model" Assessment
Policy 15-08 Assessment
MOE Technical Review
Director Supports Application
Director Does Not Support Application

Impact assessment

Impact Assessments for Areas Not Designated Under Notice 3/87

Need to have proposals assessed in a manner which is technically defensible, based on hydrogeological principles, and ensures the protection of water supplies.

Proposals must be assessed in a manner which will allow a confident decision regarding Approval or Designation

Impact Assessments for Areas Not Designated Under Notice 3/87

General Considerations

- the existing and potential uses of the receiving groundwater
- the discharge of contaminants to surface water
- the optimum orientation and location of leaching beds
- the use of new technologies

Impact Assessments for Areas Not Designated Under Notice 3/87

Components of the Assessment

Every detailed impact assessment must consider:

1) The Contaminant Source

2) The Contaminant Flow Path

3) Contaminant Attenuation

Impact Assessments for Areas Not Designated Under Notice 3/87

Components of the Assessment

THE CONTAMINANT SOURCE

- For domestic systems, the critical contaminant will normally be Nitrate

- Average daily sewage flows of 1000 l

- Effluent Nitrate concentrations = 40 mg/l

Impact Assessments for Areas Not Designated Under Notice 3/87

Components of the Assessment

THE CONTAMINANT FLOW PATH

- The most probable flow path must be defined and defended with site specific data

- The definition must include the base of the flow path/contaminant plume

- Effluent plumes must not be intercepted prior to achieving the required attenuation

ENVIRONMENT
SERVICING
DEVELOPMENT

IMPACT EVALUATIONS FOR PRIVATE SERVICES

Impact Assessments for Areas Not Designated Under Notice 3/87

Components of the Assessment

CONTAMINANT ATTENUATION

- Only dilution will be considered as a quantifiable attenuation mechanism

[illegible]

- Models may involve mixing with infiltration and groundwater along the flow path

- Estima~~s~~tes of infiltration must be based on site sp soils data

- Dilution processes within fractured media are extremely difficult to predict and shall be considered as insignificant

- The volume of sewage effluent may be include in all mass balance calculations

- Mathematical models may be applied where appropriate and where suitably defended

- Nitrate levels must not exceed 10 mg/l at the site boundary

Rv. IAH.

IMPACT EVALUATIONS FOR PRIVATE SERVICES

Impact Assessments for Areas Not Designated Under Notice 3/87

Approval Requirements

- minimum native soil thickness of 0.3 m
- spare area for bed and mantle
- the native surface deposits are not of such low K that hydraulic failure is likely

native soil T
of importance

Impact Assessments for Areas Not Designated Under Notice 3/87

General Exemptions

A detailed hydrogeological assessment of the impact potential may not be required where:

- it can be demonstrated that the septic effluent will not enter an existing or potential supply aquifer

- proposed individual lot sizes are 1 hectar or larger

ENVIRONMENT
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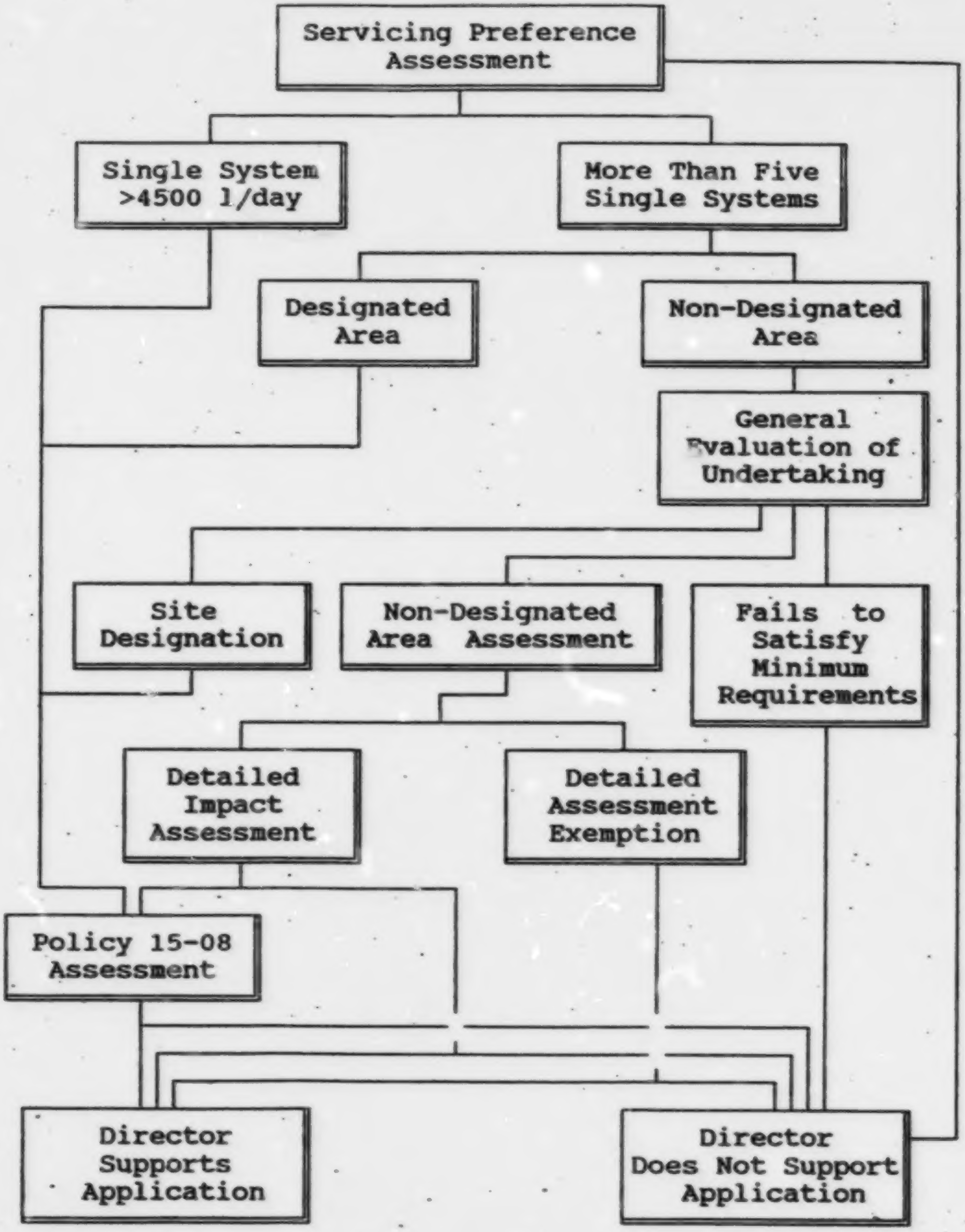
IMPACT EVALUATIONS FOR PRIVATE SERVICES


Servicing Preference Assessment
Single System >4500 l/day
More Than Five Single Systems
Designated Area
Non-Designated Area
General Evaluation of Undertaking
Site Designation
Non-Designated Area Assessment
Fails to Satisfy Minimum Requirements
Detailed Impact Assessment
Detailed Assessment Exemption
Policy 15-08 Assessment
Director Supports Application
Director Does Not Support Application

Note that at any time during the process, the Director may elect to Designate the undertaking under NOTICE 3/87

APPENDIX D PART I
TYPICAL GROUNDWATER MOUND SIMULATIONS

Groundwater Mounding

Introduction

The purpose of this analysis is to predict the groundwater mounding occurring under raised septic systems as designed following the O. Reg. 374/81 and to demonstrate that in less permeable soils higher mounds than expected will be generated. The analyses of four different scenarios is included. The four scenarios included typical septic system effluent loading of 3000 L/day for a 4 bedroom luxury house on four different terrain types. The first three terrain types are: thick sand formation (10 m), silty till matrix (5 m), clay soils (2 m) and dense clay (2 m in thickness). The three scenarios were modelled using leaching areas as prescribed by Ontario Reg.374/81 to calculate groundwater mounds generated below the beds. The three scenarios were also optimized to yield a minimum field size which would result in a mound that does not infringe on the 0.5 m unsaturated separation distance below the tiles as prescribed by Ontario Reg.374/81.

Hydrogeological Setting

The four different scenarios consisted of a total septic system flow of 3000 L/day for a septic system, that is, a fully raised bed in an imported sand fill with an hydraulic conductivity value of $K = 1 \times 10^{-3}$ cm/sec. The four scenarios differed in the material and thickness over which the leaching beds were located. The hydrogeological profile for Scenario A consisted of a 10 metre thick saturated layer of sand with an hydraulic conductivity value of $K = 1 \times 10^{-3}$ cm/sec equivalent to a percolation T time of 10-20 min/cm. An impermeable layer ($K = 1 \times 10^{-8}$ cm/sec) was assumed at a depth of 10 metres. The hydrogeological profile for Scenario B consisted of a 5 m thick saturated layer of silty till with an hydraulic conductivity value of $K = 1 \times 10^{-4}$ cm/sec equivalent to a percolation T time of 20-35 min/cm. An impermeable layer was assumed at a depth of 5 m. The hydrogeological profile for Scenario C consisted of a 2 m thick saturated layer of clay with an hydraulic conductivity value of $K = 1 \times 10^{-5}$ cm/sec equivalent to a percolation T time of 35-50 min/cm. An impermeable layer was assumed at a depth of 2 m. The hydrogeologic profile for Scenario D consisted of 2 m thick saturated layer of dense clay with a hydraulic conductivity value of $k = 1 \times 10^{-7}$ cm/sec equivalent to a percolation T-time of over 50 min/sm. An impermeable layer was assumed at a depth of 2 m. The groundwater elevations for all scenarios were assumed to be at ground elevations to simulate seasonally elevated groundwater.

Model Selection

The MODFLOW model (Modular Three-Dimensional Finite Difference Groundwater Flow Model) developed, documented and validated by the United States Geological Survey (MacDonald & Harbaugh) was used in the groundwater mounding analysis.

Conceptual Model

The conceptual model consisted of a 30 row x 30 columns uniformally spaced grid (see Figure D-I-1). The proposed septic system was discretized in 10 m x 10 m grid elements centrally located in the model. The base of the aquifer for each scenario was simulated by assuming an impermeable layer was located below the material. The boundary conditions were set to equal constant heads at all boundaries in order to simulate a relatively flat overburden with radial flow away from the beds. Original ground surface elevations were assumed flat at elevation 100.0 metres.

Input Parameters

The initial heads were set at elevation 100.01 m to simulate seasonally elevated groundwater elevations. Areal recharge from precipitation was neglected due to the assumption of seasonally elevated groundwater as initial heads. No evapotranspiration was used in order to simulate worst case conditions for mounds.

The aquifer was assumed to be isotropic with regard to the permeability in the x and y directions. The storativity was set equal in all grid elements for each layer. The storativity (i.e. effective porosity) was assumed to be 30% for the imported sand fill and native 10 m sand layer, 20% for the silty till layer and 10% for the clay layer and dense clay (Fetter, 1988).

The loading of the septic system leaching bed was simulated by specifying an inflow unit discharge for each grid elements located under the proposed septic system footprint. One year transient simulations runs were performed using inflow rate of 3000 L/day (4 bedroom luxury house) effluent flow rate over leaching bed sizes as specified by O.Reg.374/81. The required septic systems areas for each scenario are as follows using the O.Reg.374/81 formulae L = QT/200, where L is the length of distribution pipes (m), Q is the proposed 4 bedroom luxury house effluent and fow rate (L/day) with spacing of 1.6 m between lines: and T is the percolation times of the native soil (min/cm).

Scenario A: T = 10 min/cm
Q = 3000 L/day

L = 3000 x 10/200

L = 150 m
7 lines a 21.5 m w/ 1.6 m spacing
Area = (7-1) x 1.6 x 21.5 = 206.4
say 200 m^2

Scenario B: T = 35 min/cm
Q = 3000 L/day

L = 3000 x 35/200
L = 525 m
18 lines @ 29.2 m w/1.6 m spacing
Area = (18-1) x 1.6 x 29.2 = 794 m^2
say 800 m^2

Scenario C and D: T = 50 min/cm
Q = 3000 L/day

L = 3000 x 50/200
L = 750 m
25 lines @ 30 m w/1.6 m spacing
Area = (25-1) x 1.6 x 30 = 1152 m^2
say 1200 m^2

A vertical separation of 0.9 m was assumed between the bottom of the leaching bed and the seasonally elevated groundwater, to allow the mound to rise. It was compared with the maximum unsaturated distance of 0.5 m quoted in the guidelines.

Results

The groundwater modelling of the required leaching bed areas resulted in mounds of 0.25 m for scenario A (sand), 0.73 m for scenario B (till), 0.93 m for scenario C (clay) and 0.99 m for scenario D (see Figures D-I-2, D-I-4, D-I-7, and D-I-10 respectively). Additional simulations were performed in order to optimize the leaching area resulting in a maximum mound of 0.4 m. The resulting optimizing runs yielded field sizes of 3200 m^2 for scenario B and 8100 m^2 for Scenario C (see Figures D-I-6 and D-I-9). Scenario A already produces a mound which is less than 0.4 m high.

Discussion

The separation of 0.9 m between the seasonally elevated groundwater and the bottom of the leaching bed was provided in order to allow a maximum mound of 0.4 m therefore resulting in an available unsaturated thickness of 0.5 m between the bottom of the bed and the maximum mounded groundwater elevation.

Scenario A, as designed according to O.Reg.374/81, resulted in a mound of 0.25 which is below the 0.4 m maximum elevation required for this study. Studies show that a mound of 0.2 m is generally expected in this material (Canter et al. 1986). Scenario B and C and D resulted in mounds of 0.73, 0.93 m, and 0.99 m respectively. Therefore the separation of 0.5 m unsaturated soil would be saturated by the high mounds. An additional vertical separation of 0.33 m, 0.53, and 0.59 m would be required for scenarios B, C and D respectively.

The area covered by the mounding for scenario A, B, C and D as limited by the design criteria of O.Reg.374/81 were 0.7, 1.5, 1.6 and 2.1 hectares respectively. The scenarios for optimization resulted in a mounding area of 1.7 and 1.8 hectares for scenarios B and C respectively. Simulation runs on an aquifer thickness of 0.3 m for the first three scenarios resulted in mounding of 1.06 m for Scenario A, 0.73 for Scenario B and 0.93 m for Scenario C. This resulted in mounding areas of 1.4 ha, 1.5 ha and 1.6 ha for scenario A, B and C respectively, (see Figures D-I-3, D-I-5 and D-I-8, and Table D-I-1).

The results of the analysis were sensitive to the selection of the hydraulic conductivity, specific yield and soils thicknesses. A higher hydraulic conductivity for the imported fill (K = 1 x 10^{-2} cm/sec) would result in a lesser mound but the mounding area would be increased. The value of storativity estimated for each layer are reasonable selections as listed in Applied Hydrogeology (Fetter,1988). The scenarios simulated represented typical soils and thicknesses. For thinner soils, the mounds generated were higher for the sand aquifer, but remained unchanged for the silty till and clay aquifer.

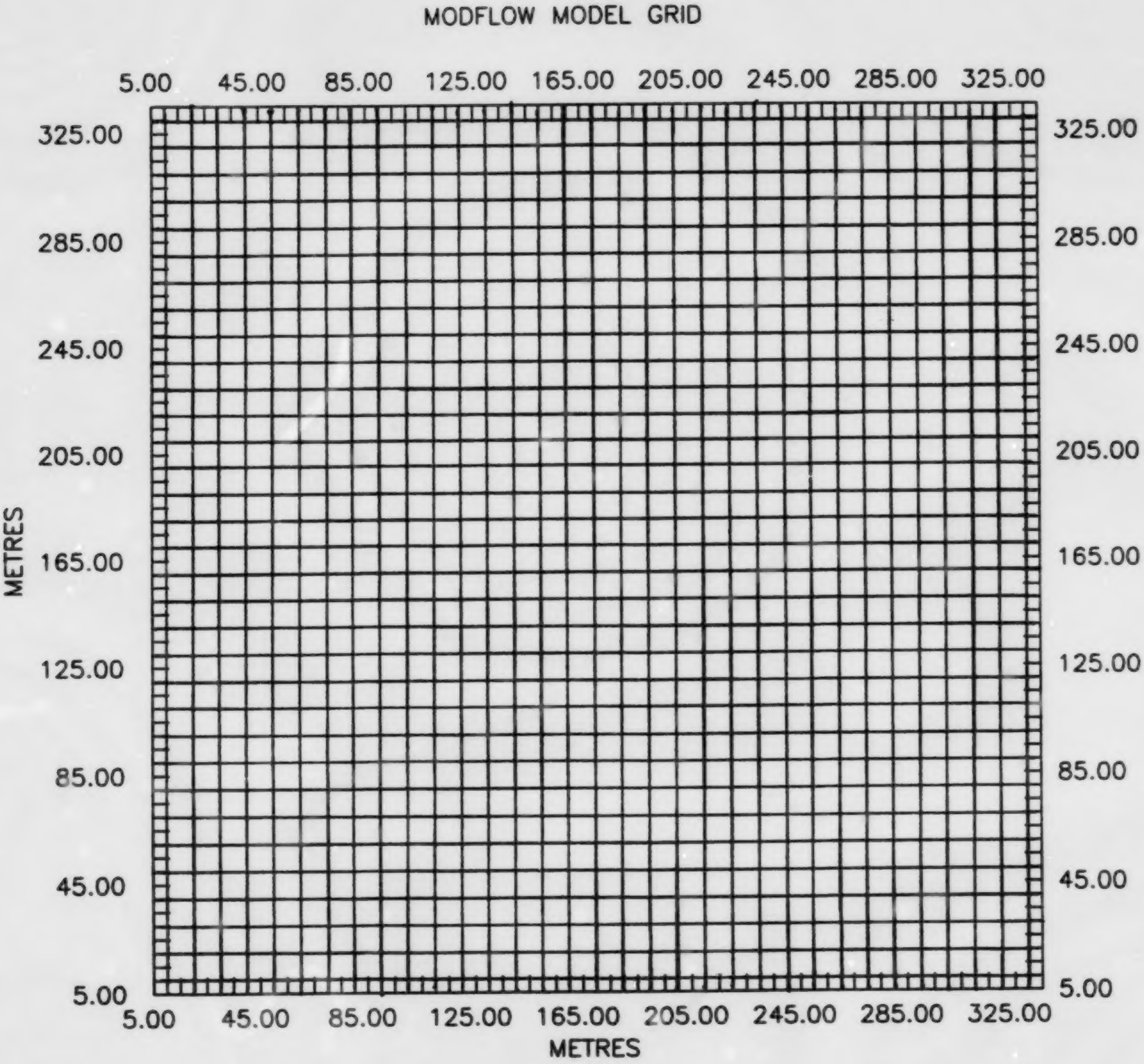
Conclusions

The scenarios simulated demonstrated that in less permeable soils (Scenario B, C and D), limited by design criteria as listed in O.Reg.374/81, higher mounds than expected are generated (Table D-I-1). It is also demonstrated that the limiting mounding criteria can be attained by designing a bed which covers a larger area (i.e. lower loading rate). The other solution would be to keep the same design criteria but increase the vertical separation distance between maximum groundwater and bottom of the leaching beds. The extent of the mounds produced by scenario A, B, C and D results in large lot sizes if no effluent is to migrate to neighbouring properties. Therefore, in finer material (Scenario B, C and D), it is recommended that the separation between maximum groundwater elevation and the bottom of the leaching bed be increased in the range of 0.5 m or that the bed size design criteria be increased by a factor of 4 for the scenario B type material and 6 times for the scenario C type material.

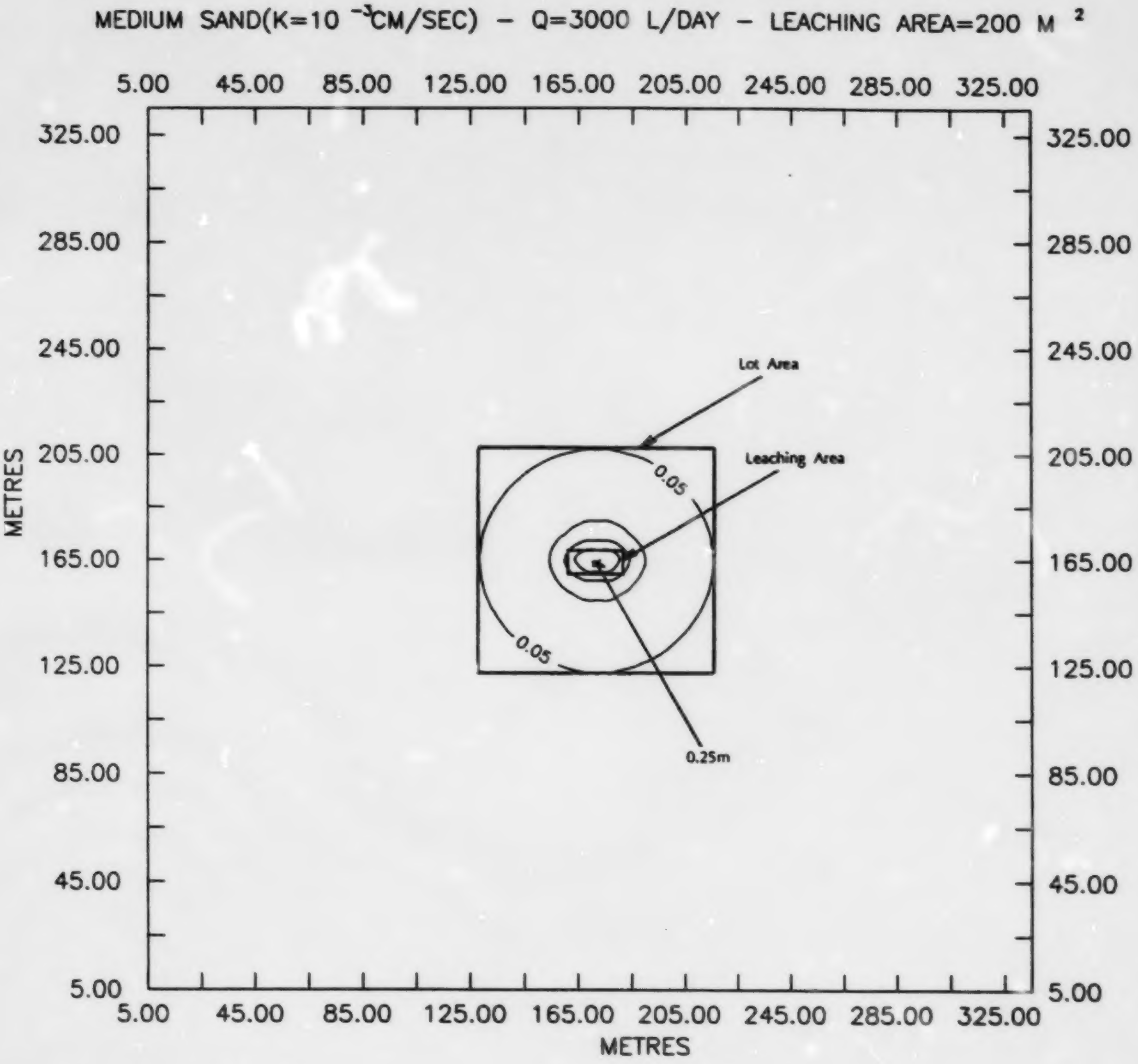
TABLE D-I-1
LOT SIZE DETERMINATION

SOIL TYPE			AREA (ha)	MAX. MOUND (m)
Medium	sand	(10 m thick)	0.7	0.25
	silt	(5 m thick)	1.5	0.73
Optimized	silt	(5 m thick)	1.7	0.42
	clay	(2 m thick)	1.6	0.93
Optimized	clay	(2 m thick)	1.8	0.
	dense clay	(2 m thick)	2.1	0.99

Note: Optimized version includes a back computation of the loading rate and the bed area to ensure no more than 0.4 m of mounding.


MODFLOW MODEL GRID
5.00
45.00
85.00
125.00
165.00
205.00
245.00
285.00
325.00
METRES
METRES

MODFLOW MOUNDING GRID FOR MOUNDING SIMULATION	**Figure D-I-1**
	Geo-analysis Inc. Groundwater Consultants
	Project No. G9105



MOUNDING SIMULATION FOR MEDIUM SAND (10m) [Scenario A]

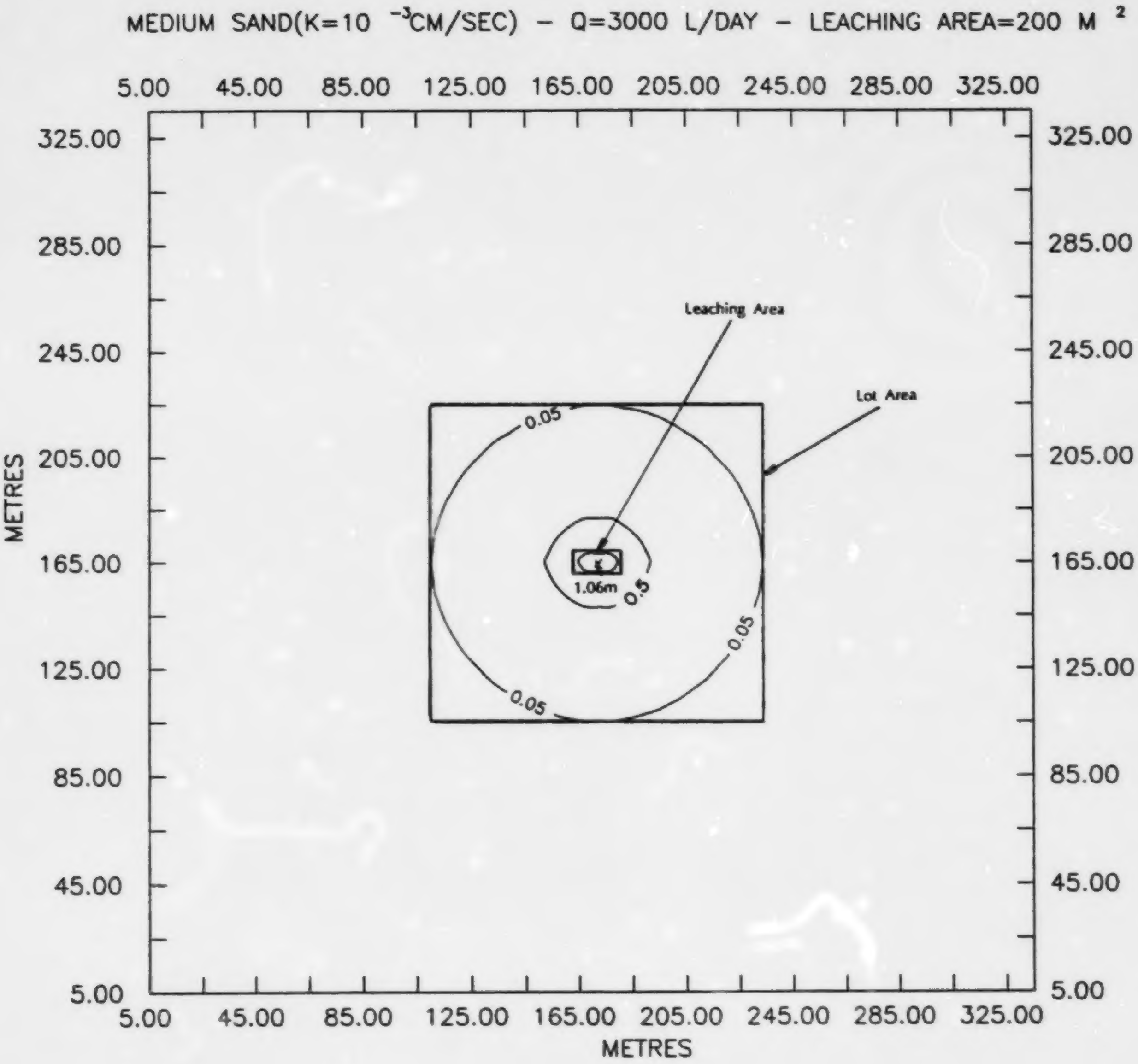
Lot Size = 0.7 ha

Maximum Mound = 0.25m

Figure D-I-2

Geo-analysis Inc.
Groundwater Consultants

Project No. G9105



MOUNDING SIMULATION FOR
MEDIUM SAND (1.2m)
[Scenario A on 1.2m Sand]

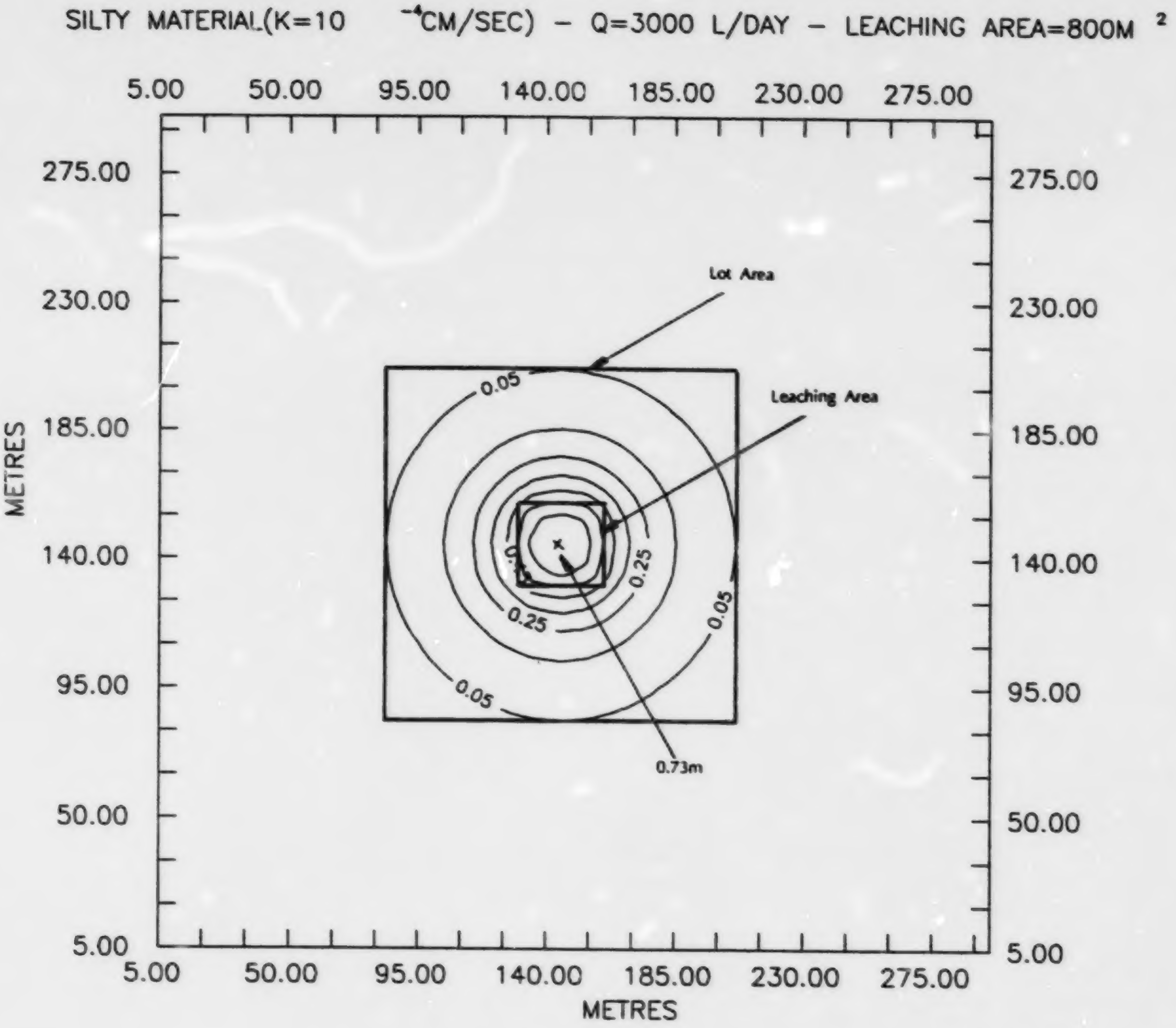
Lot Size = 1.4 ha

Maximum Mound = 1.06m

Figure D-I-3

Geo-analysis Inc.
Groundwater Consultants

Project No. G9105



MOUNDING SIMULATION FOR SILTY MATERIAL (5m) [Scenario B]

Lot Size = 1.5 ha

Maximum Mound = 0.73m

Figure D-I-4

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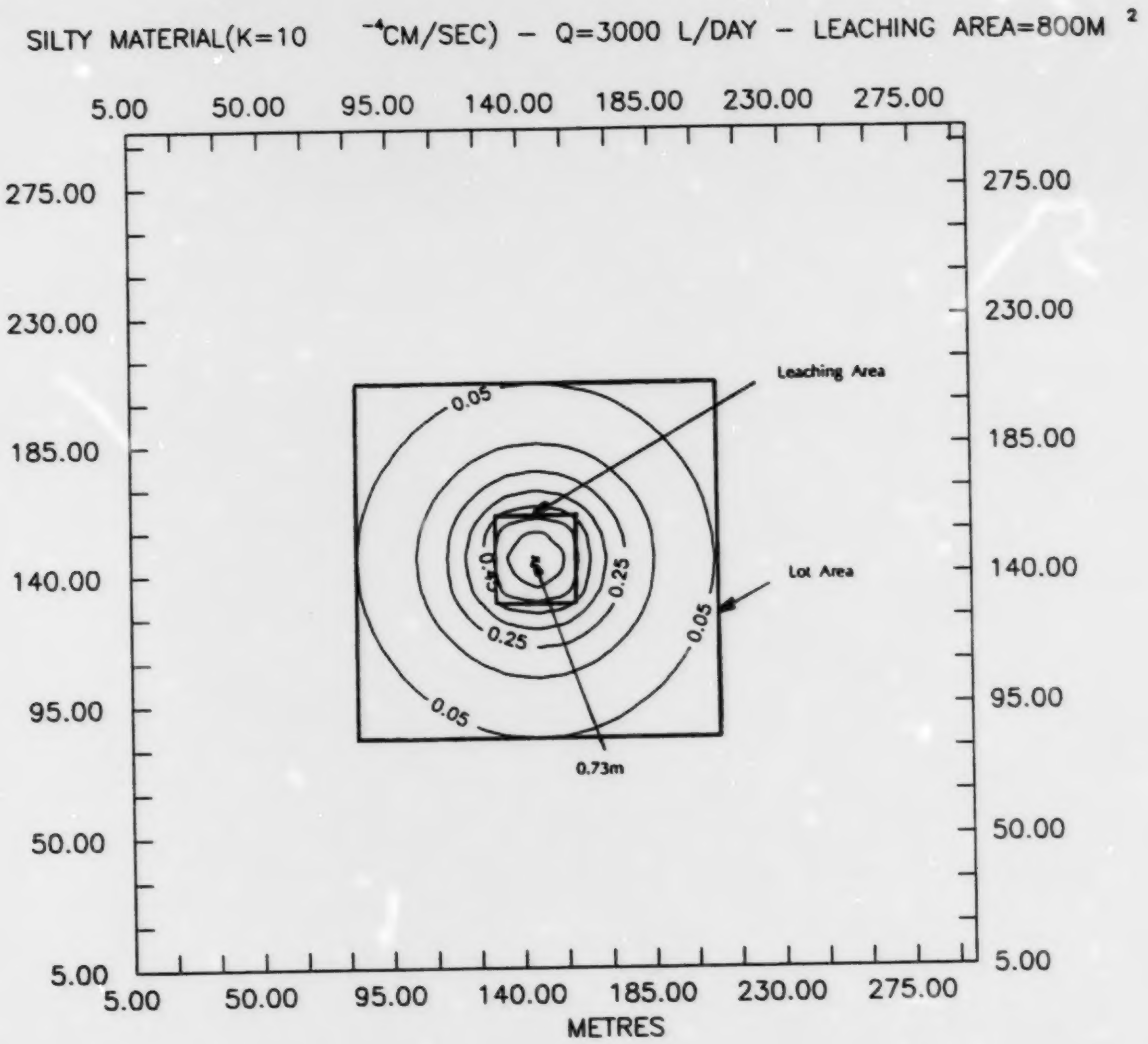


MOUNDING SIMULATION FOR SILTY MATERIAL (1.2m)
[Scenario B on 1.2m Silt]

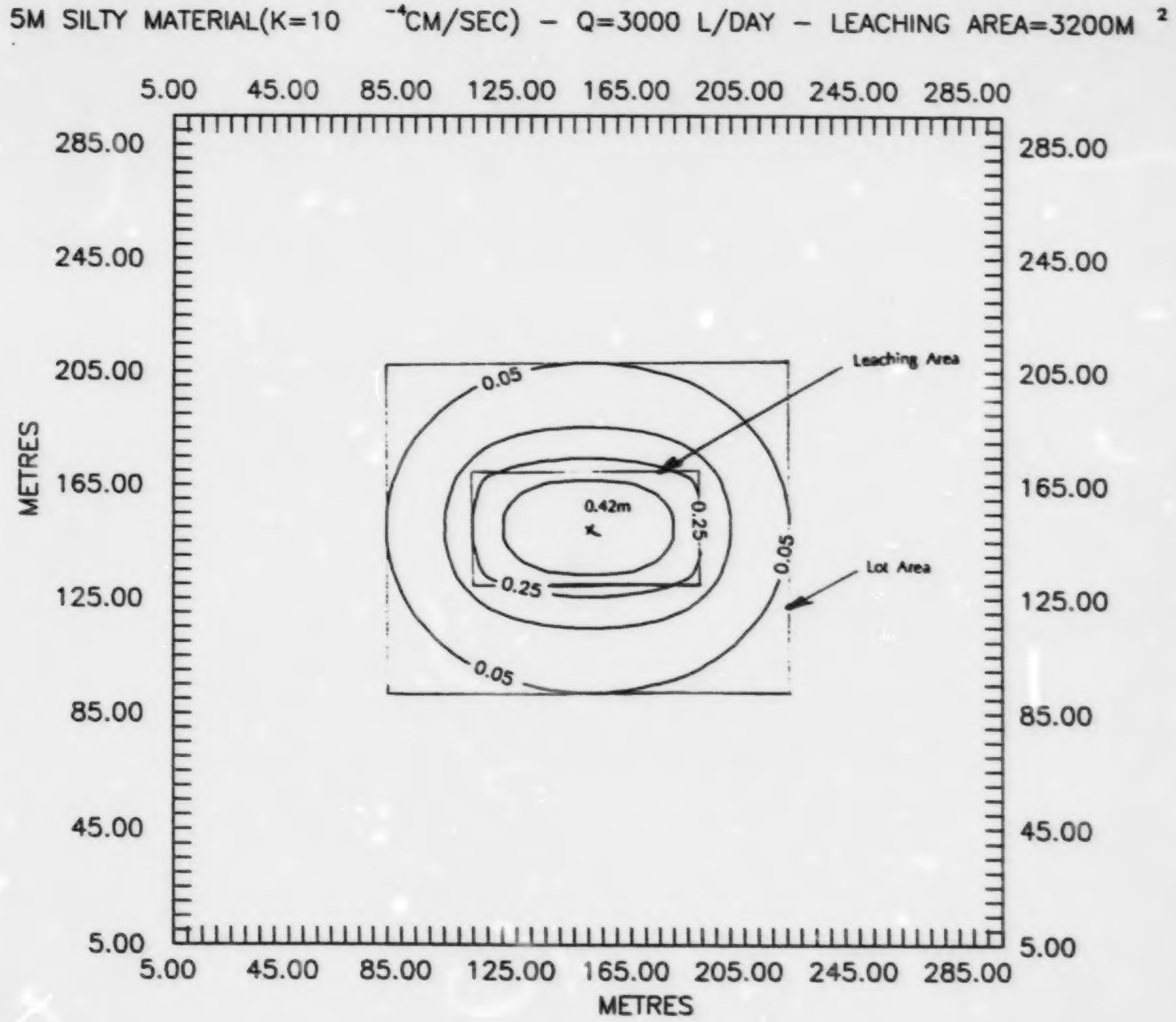
Lot Size = 1.5 ha

Maximum Mound = 0.73m

Figure D-I-5

Geo-analysis Inc.
Groundwater Consultants

Project No. G9105



OPTIMIZATION - is solving for the leaching area that will generate less than 0.4m of mound over the ground surface.

MOUNDING SIMULATION FOR SILTY MATERIAL OVER LEACHING AREA OF 3,200m^2 [Scenario B with Optimization]

Lot Size = 1.7 ha

Maximum Mound = 0.42m

Figure D-I-6

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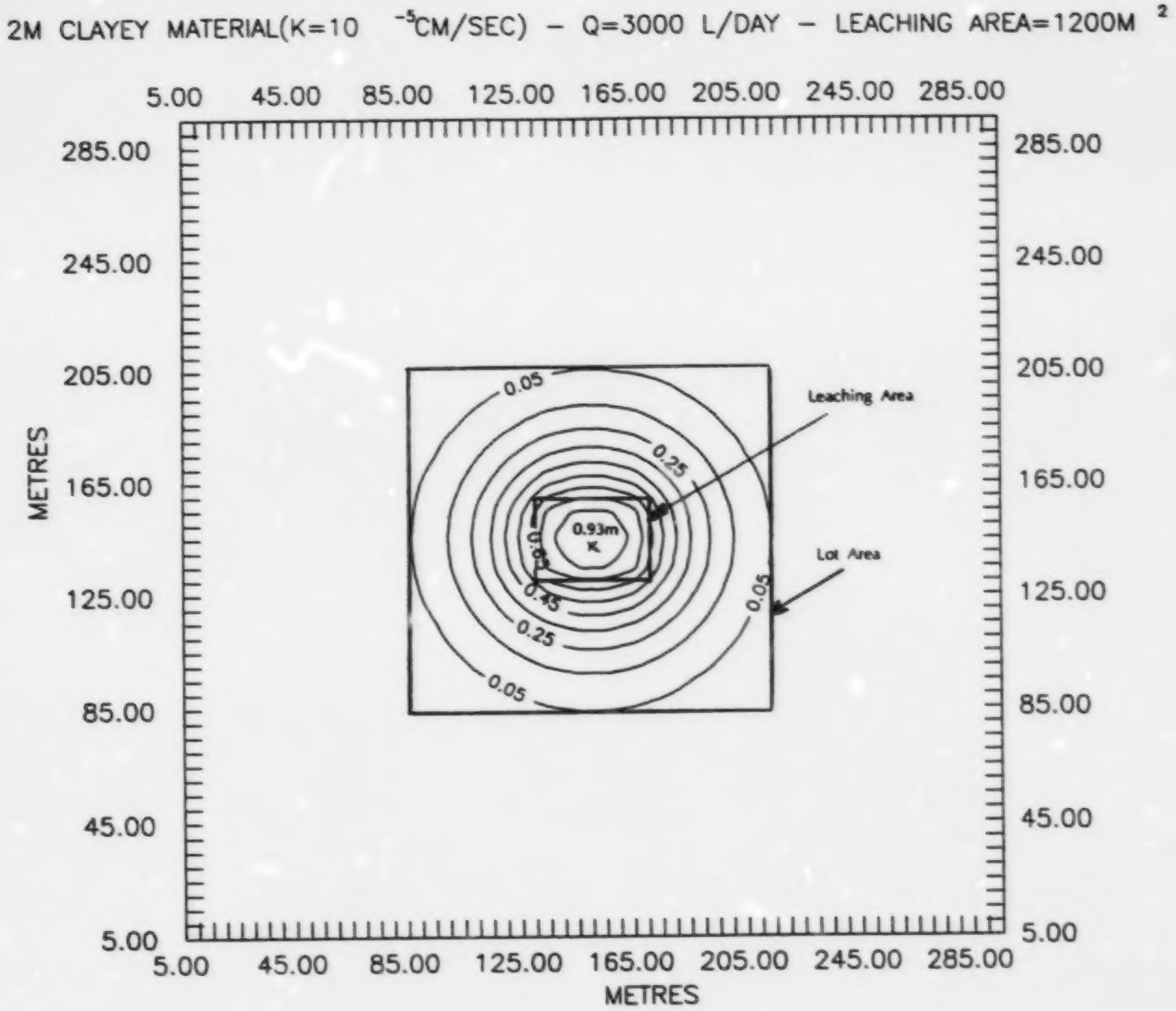
Groundwater Consultants

Project No. G9105



MOUNDING SIMULATION FOR CLAYEY MATERIAL (2m) [Scenario C]

Lot Size = 1.6 ha

Maximum Mound = 0.93m

Figure D-I-7

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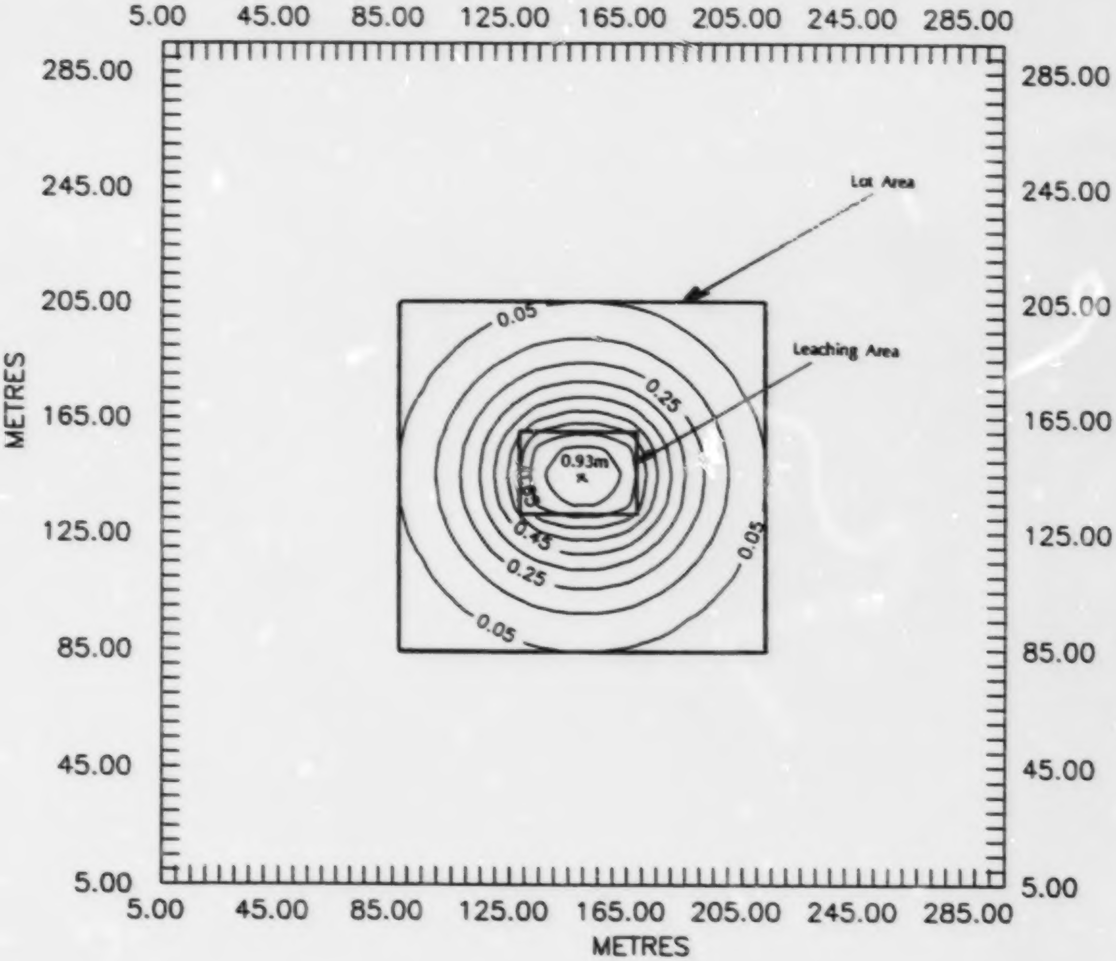
Groundwater Consultants

Project No. G9105

CLAYEY MATERIAL($K=10^{-5}$CM/SEC) - Q=3000 L/DAY - LEACHING AREA=1200M^2



MOUNDING SIMULATION FOR
CLAYEY MATERIAL (1.2m)
[Scenario C on 1.2m Clay]

Lot Size = 1.6 ha

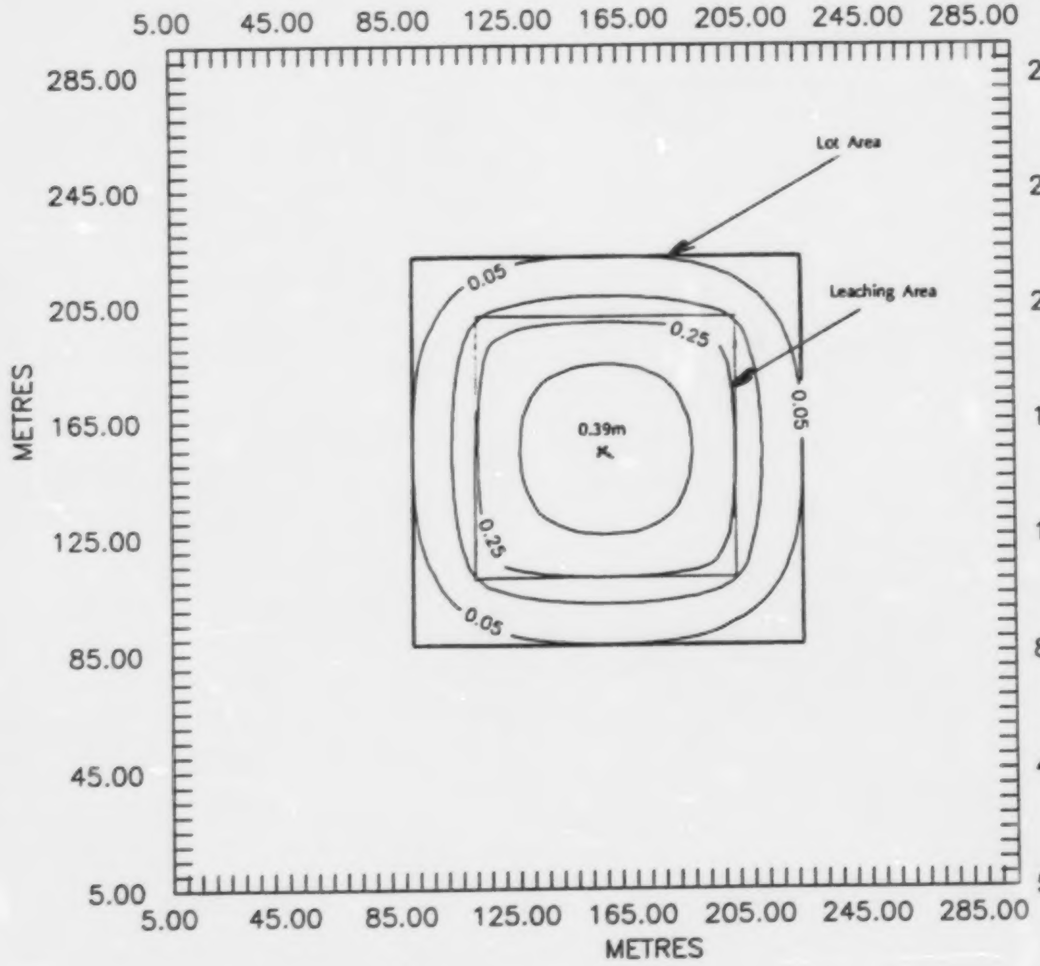
Maximum Mound = 0.93m

Figure D-I-8

Geo-analysis Inc.
Groundwater Consultants

Project No. G9105

2M CLAYEY MATERIAL($K=10^{-5}$CM/SEC) – Q=3000 L/DAY – LEACHING AREA=8100M^2



OPTIMIZATION - is solving for the leaching area that will generate less than 0.4m of mound over the ground surface.

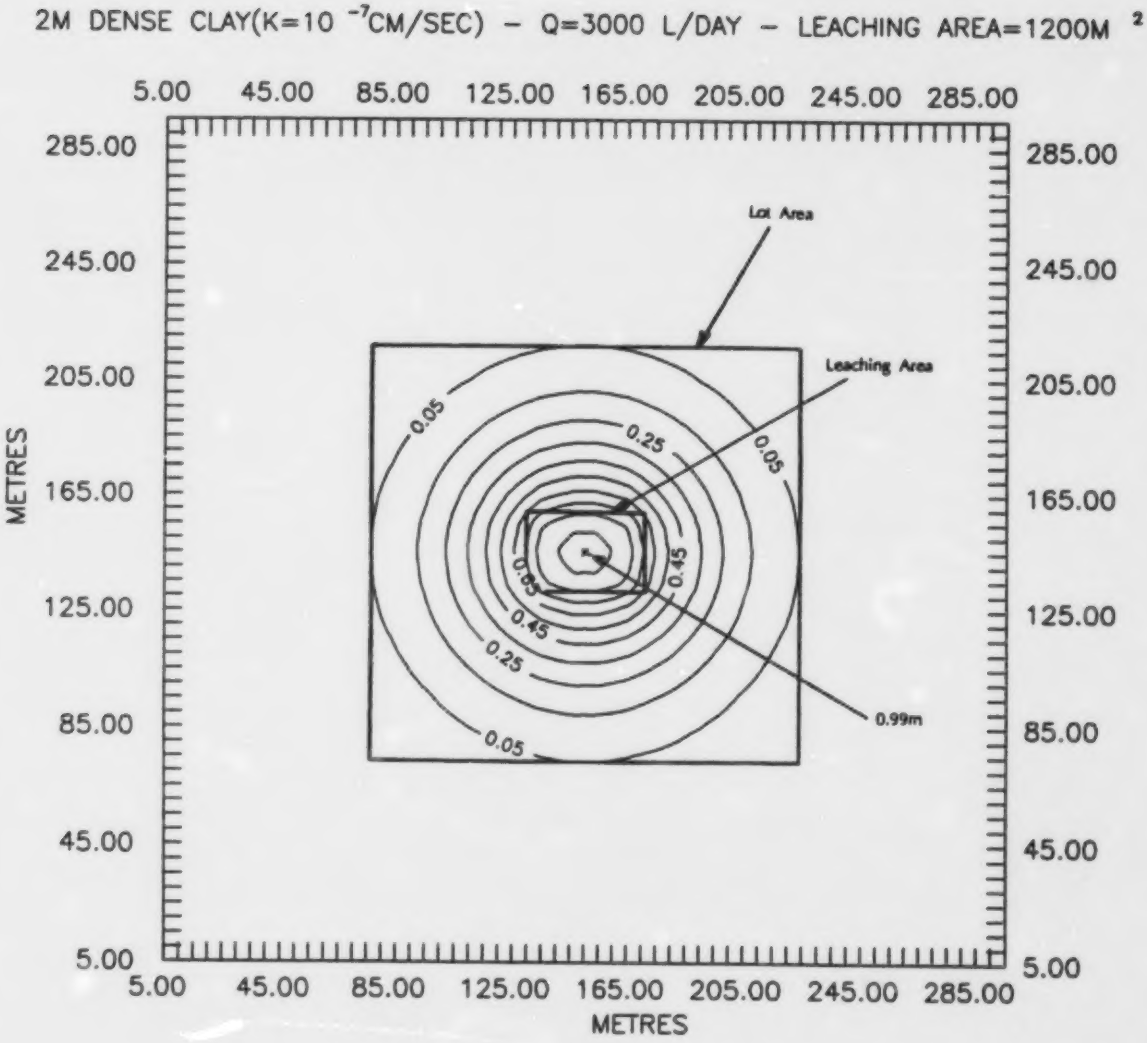
MOUNDING SIMULATION FOR
CLAYEY MATERIAL (2m) OVER LEACHING
AREA OF 8,100m^2
[Scenario C with Optimization]

Lot Size = 1.8 ha
Maximum Mound = 0.39m

Figure D-I-9

Geo-analysis Inc.
Groundwater Consultants

Project No. G9105



MOUNDING SIMULATION FOR DENSE CLAY MATERIAL (2m)
[Scenario D]

Lot Size = 2.1 ha

Maximum Mound = 0.99m

Figure D-I-10

Geo-analysis Inc.
Groundwater Consultants

Project No. G9105

APPENDIX D PART II
TYPICAL NITRATE LOADING SIMULATIONS

Nitrate Loading

Introduction

The purpose of this analysis is to predict the nitrate loading and movement of the nitrate in the overburden aquifer. The analyses of four different scenarios is included. The four scenarios consist of typical septic system effluent nitrate loading of 1000 L/day at a concentration of 40 mg/L for a 4 bedroom luxury house on four different terrain types. The terrain types are: thick sand and gravel formation (10 m), thick sand formation (10 m), silty till matrix (5 m) and clay soils (2 m in thickness).

Hydrogeological Setting

The four different scenarios consisted of a total septic system effluent nitrate loading of 1000 L/d at a concentration of 40 mg/L. The four scenarios differed in the material and thicknesses over which the leaching beds were located. The hydrogeological profile for Scenario A consisted of a 10 metre thick layer of saturated sand and gravel with an hydraulic conductivity value of $K = 1 \times 10^{-2}$ cm/sec equivalent to a percolation time of 5-10 min/cm. The hydrogeological profile for Scenario B consisted of a 10 m thick layer of saturated sand with a hydraulic conductivity value of $K = 1 \times 10^{-3}$ cm/sec equivalent to a percolation time of 10-20 min/cm. An impermeable layer ($K = 1 \times 10^{-8}$ cm/sec) is assumed at a depth of 10 metres for Scenario A and B. The hydrogeological profile for Scenario C consisted of a 5 m thick layer of saturated silty till with an hydraulic conductivity value of 1×10^{-4} cm/sec equivalent to a percolation T time of 20-35 min/cm. An impermeable layer is assumed at a depth of 5 m. The hydrogeological profile for Scenario D consisted of a 2 m thick layer of saturated clay with an hydraulic conductivity value of $K = 1 \times 10^{-5}$ cm/sec equivalent to a T time of 35-50 min/cm. An impermeable layer is assumed at a depth of 2 m. A groundwater gradient of 0.003 was assumed for all scenarios.

Model Selection

The MOC model (Computer Model of Two-Dimensional Solute Transport and Dispersion in Ground Water) developed, documented and validated by the United States Geological Survey (Konikow et al, 1984) was used in the groundwater nitrate loading analysis.

Conceptual Model

The conceptual model consisted of 20 row x 20 columns uniformally spaced grid (see Figure D-II-1). The proposed septic system nitrate loading was discretized as a point source centrally located in a 40 ft x 360 ft. (12 m x 110 m) grid element. The aquifer thicknesses for each scenario was assumed to be 10 m for Scenario A and B, 5m for Scenario C and 2 m for Scenario D. The boundary conditions were set to constant head elevations to the easterly and westerly boundary in order to provide a 0.003 groundwater gradient to the simulated aquifers.

Input Parameters

The aquifer was assumed to have longitudinal dispersivity of 1 m, transverse horizontal dispersivity of 0.1 m and transverse vertical dispersivity of 0.004 m (Cherry et al, 1991). The storativity was set equal in all grid elements. The storativity was assumed to be 30% for the 10 m thick sand and gravel layer, and the 10 m sand layer, 20% for the silty till layer and 10% for the clay layer (Fretter, 1988).

It was assumed that no background nitrate concentrations existed in the aquifers. All simulations were for 30 years steady-state with no recharge to account for worst case scenarios. It was further assumed that no denitrification took place, as required by MOE Guidelines.

Results

The groundwater nitrate loading simulations resulted in a thin long plume (22 m x 1000 m) for Scenario A (sand and gravel) similar to that simulated by Cherry et al, 1991. The area of the plume was about 2.2 ha. The extent of the plume which resulted in a 2.5 mg/L nitrate concentration was 1000 m in the direction of flow and 25 m perpendicular to the direction of flow (see Figure D-II-2). The nitrate loading simulation for Scenario B (sand) resulted in a thin long plume with 2.5 mg/L nitrate concentration extending approximately 320 m in the direction of flow and 50 m perpendicular to the direction of the flow (see Figure D-II-3).

The 2.5 mg/L nitrate loading plume for Scenarios B (till) and C (clay) generated a slightly elongated plume under very high gradients (Figure D-II-5; D-II-6).

Additional simulations were performed in which Scenario B had a constant saturated thickness of 1.2 m overlying a competent impermeable bedrock surface. Because of the thin sand, it is not perceived to have a potential for aquifer use, and a nitrate criteria 10 mg/L NO_3-N was selected. The additional simulations yielded the following results. For Scenario B (sand), the 10 mg/L NO_3-N plume area was about 2.8 ha with a long axis equal to 500 m.

The level of confidence of flowthrough assessment on the bedrock aquifer is low. Fracture flows in the bedrock will generate little attenuation in this high velocity environment.

Discussion

The above results demonstrated that thin long plumes can be expected in these sand aquifers. It can be seen that as the aquifer thickness decreases, a wider and longer plume will develop. While simulating the clay and till scenarios, excessive unrealistic mound occurred. Despite these mounds, the plumes generated in the silty tills and clays did not travel far.

The results of the analysis were sensitive to the selection of the hydraulic conductivity, specific yield, soil thickness, groundwater gradient, groundwater velocity and longitudinal and transversal dispersivity. The value of storativity estimated for each layer are reasonable selections as listed in Applied Hydrogeology (Fretter 1988). The scenarios simulated represented typical soil and saturated thicknesses. For thinner aquifer thickness, longer and wider plume would be generated.

The selected groundwater gradients were typical values of gradients, for lower gradients and/or velocities, the plume generated would be reduced in length but would increase in width. The longitudinal and transversal dispersivity values utilized were typical values for sand aquifers as demonstrated by Cherry et al, 1991. Higher values of longitudinal and transversal dispersivities would result in wider plumes.

Conclusions

The scenarios simulated demonstrated that in higher hydraulic conductivity soils (Scenarios A and B) nitrate loading of 1000 L/d at concentration of 40 mg/L promoted long and thin plumes in permeable soils. A corresponding minimum lot size of 1.7 to 2.2 ha was generated in order to meet the Reasonable Use Criteria of 2.5 mg/L NO_3-N at the down gradient property boundary. It is also shown that plume areal extent increased as the saturated thickness of the aquifer decreased. The extent of the plumes to which the nitrate concentrations exceeds 10 mg/L NO_3-N resulted in large lot sizes. Corresponding minimum lot size of 2.8 ha was generated on thin sand overlying competent impermeable bedrock surface. Therefore, it is recommended that in permeable soils, lot shapes and sizes are carefully planned in order that the nitrate attenuation zones can be contained (i.e. long and narrow) (Table D-II-1). The intergration of the groundwater flow behaviour is imperative in the delineation of lot geometry.

Common Sense Hydrogeology Recommendations:

These assessments represent worst case scenarios. All input parameters were evaluated to represent reality to the best of our knowledge. It is suggested that any development on smaller lots be phased-in with a built-in buffer as contingency. Nitrate loading and plume generation should be monitored for 2 years for the extent of the 2.5 mg/L NO_3-N plume. If the natural systems perform better than predicted, then a higher density would be identified in the subsequent phases.

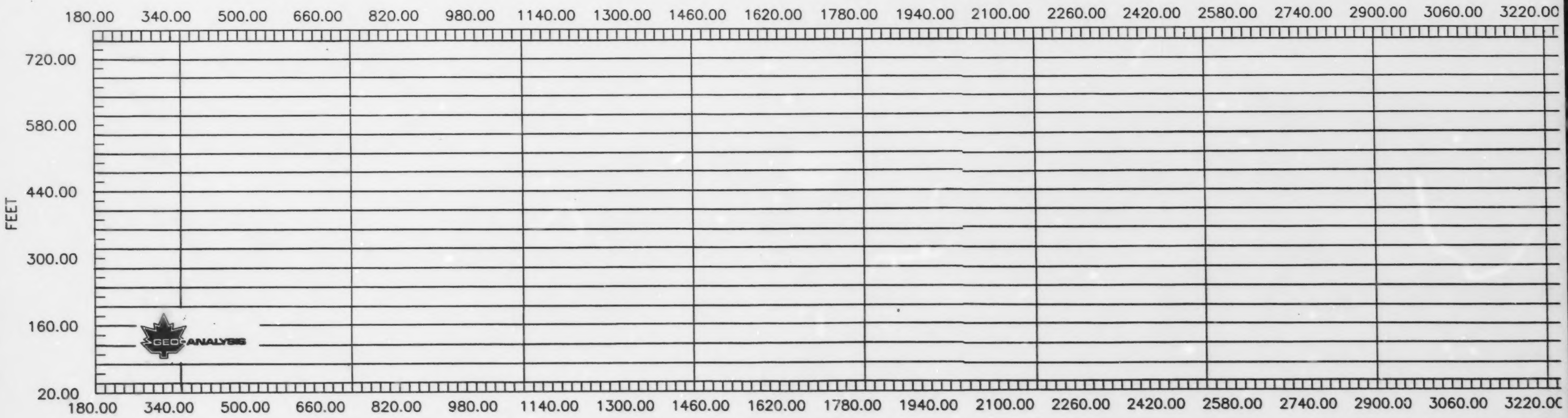
TABLE D-II-1
LOT SIZE SUMMARY

ASSUMPTIONS:
i = 0.003, constant head
n = 10 to 30
k = 10^{-5} to 10^{-2} cm/sec
$_{L}$ = 1 m
$_{TH}$ = 0.1
$_{TV}$ = 0.004

TABLE D-II-1
LOT SIZE SUMMARY

SOIL TYPE	LOT SIZES 2.5 mg/L NO_3-N	10 mg/L NO_3-N
Sand Granules (10 m thick)	2.2 ha (1000 m x 22 m)	0.23 ha
Sand (10 m thick)	1.6 ha (320 x 50 m)	0.8 ha
Sand (1.2 m thick)	4.8 ha (600 x 80 m)	2.8 ha

MOC MODEL GRID
FOR NITRATE LOADING SIMULATION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500.00
660.00
820.00
980.00
1140.00
1300.00
1460.00
1620.00
1780.00
1940.00
2100.00
2260.00
2420.00
2580.00
2740.00
2900.00
3060.00
3220.00
720.00
580.00
440.00
300.00
160.00
20.00
FEET
GEO-ANALYSIS

Figure D-II-1

Geo-analysis Inc.
Groundwater Consultants
Project No. G9105

NITRATE LOADING SIMULATION
(Scenario A)

Lot Area: 2.2 ha
(2.5 mg/L NO_3-N)

Lot Area: 0.2 ha
(10 mg/L NO_3-N)

SAND & GRAVEL($K=10^{-2}$CM/SEC) – Q=1000 L/DAY – NO_3–N=40MG/L – i=.003

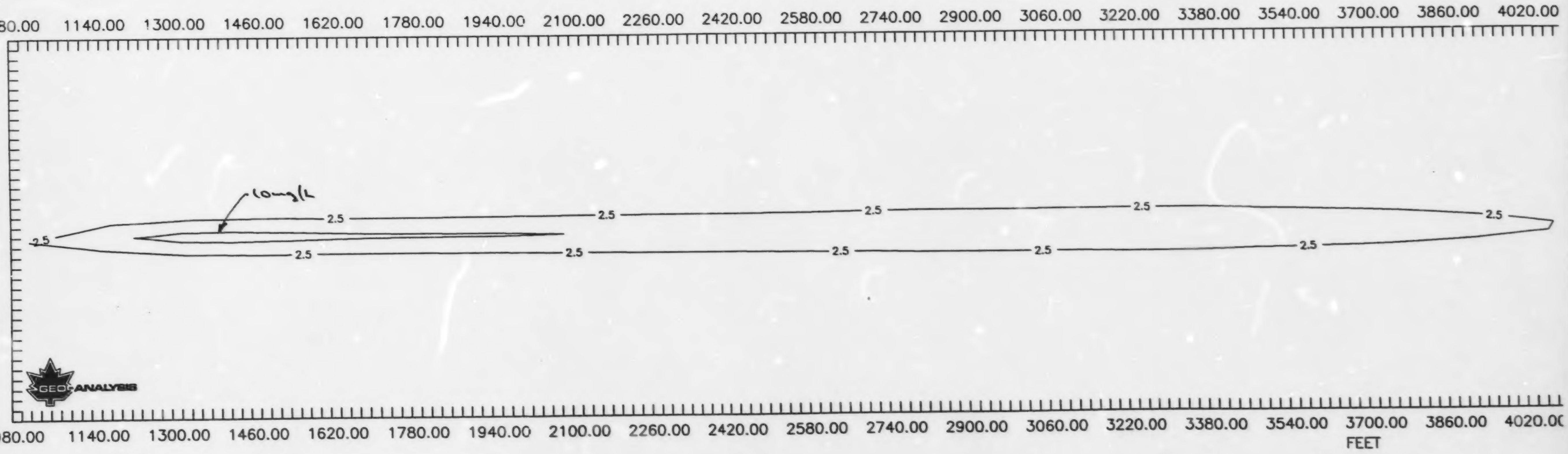

Figure D-II-2

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Groundwater Consultants
Project No. G9105

NITRATE LOADING SIMULATION ON SAND (10m)

[Scenario B]

Lot Area: 1.6 ha
(2.5 mg/L NO_3-N)

Lot Area: 0.8 ha
(10 mg/L NO_3-N)

MEDIUM SAND(K=10 $^{-3}$CM/SEC) – Q=1000 L/DAY – NO_3–N=40MG/L – i=.003

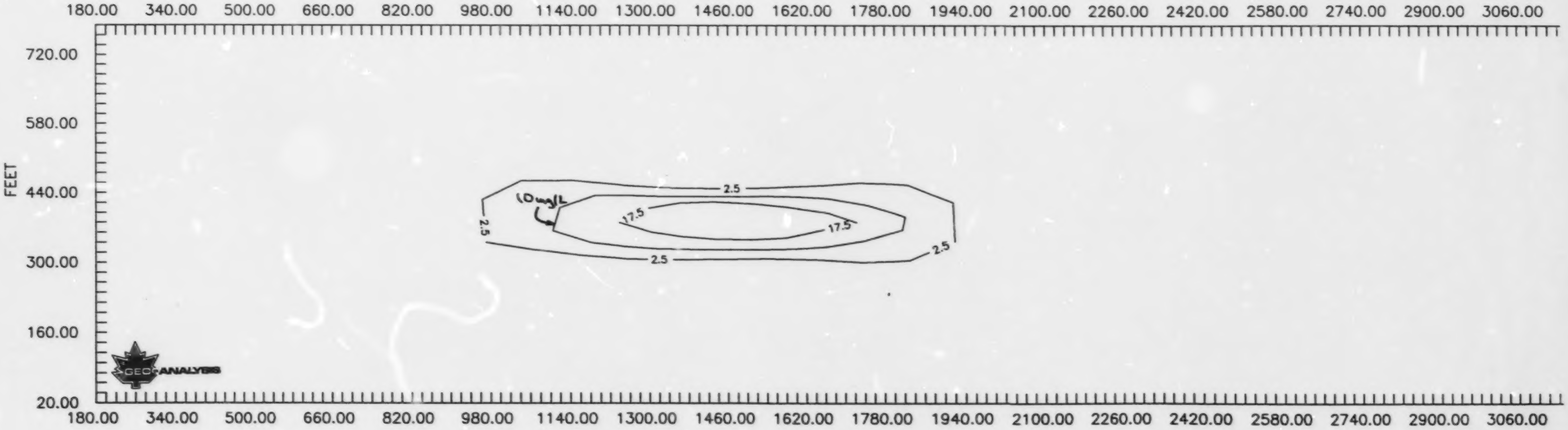

Figure D-II-3

Geo-analysis Inc.
Groundwater Consultants

NITRATE LOADING SIMULATION ON SAND (1.2m)
[Scenario B on 1.2m Sand]

Lot Area: 4.8 ha
(2.5 mg/L NO_3-N)

Lot Area: 2.8 ha
(10 mg/L NO_3-N)

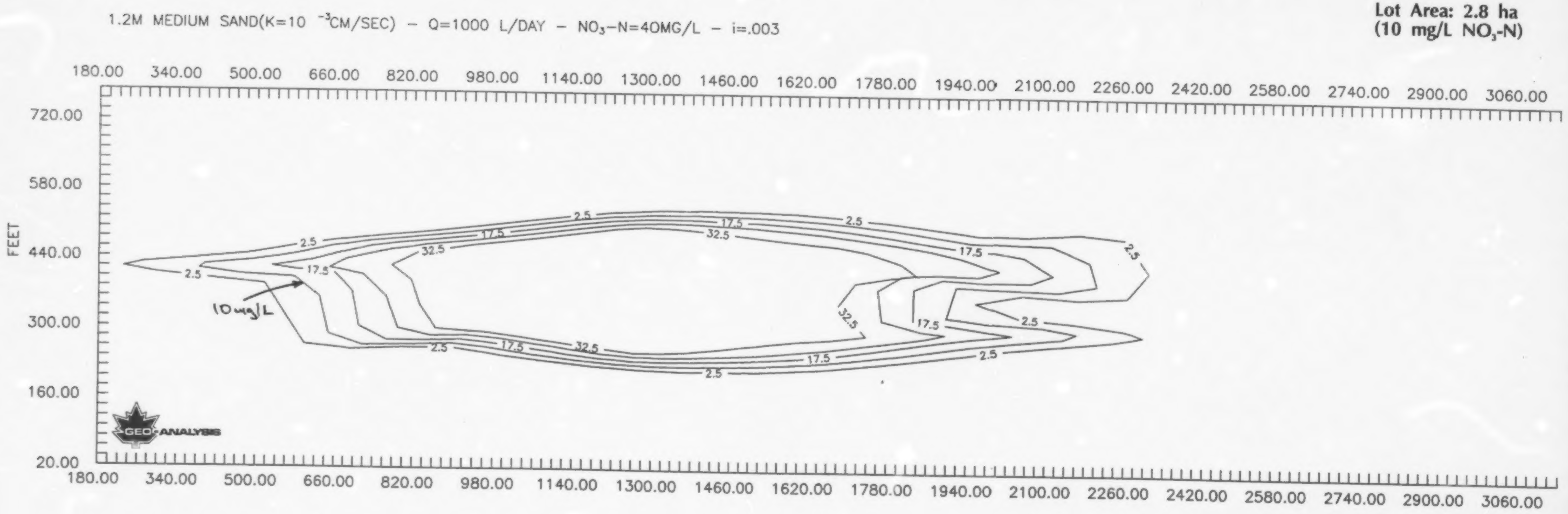

Figure D-II-4

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Project No. G9105

APPENDIX E
BIBLIOGRAPHY AND LISTING OF MOE SUBDIVISION REPORT NUMBERS UTILIZED IN THIS STUDY

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LIST OF CONTENTS

DATE	BRIEF DESCRIPTION OF TOPIC	CONTACT	OFFICE
May 15, 1991	- meeting in Casselman	Patrice Dupont	Health Unit
May 8, 1991	- meeting, Part VIII Review of Draft No. 2 Guidelines	Kirk Hansen	MOE
May 6, 1991	- meeting	Brian Cooper	MOE
June 17, 1991	- meeting W.O.C. Health Unit - report objection, input, anticipated output	John Goold and Al Raven	Health Unit
May 10, 1991	- meeting W. Leeds Grenville Lanark District Health Unit - Draft No. 2 mentioned	Jim Craig & Henry Garcia	Health Unit
July 29, 1991	- meeting @ RMOC Planning Department Conference Room - rev. Terms of Reference, Project Status, time schedule	Leslie Paterson	
May 24, 1991	- brief meeting - request for RMOC rural maps	Kirk Hansen	MOE
June 3, 1991	- phone conversation - re. heat pumps	Derrick VanderMeer	Ontario Hydro
Jan. 10, 1991	- phone conversation - request for hydrog. reports	Alida Mitton	
une 28, 1991	- phone conversation - request for RMOC rural area map with H_20 quality and quantity problems	George Clark	MOE

APPENDIX F

BASIN

LAKE ONTARIO

1101 Lake Ontario
1102 Trent River
1103 Moira River
1104 Salmon River
1105 Napanee River
1106 Cataraqui River
1107 Prince Edward County

ST LAWRENCE RIVER

1201 St Lawrence R.
1202 Gananoque R.
1203 Raisin R.
1204 Delisle R.

OTTAWA RIVER

1301 Ottawa R.
1302 Bonnechere R.
1303 Madawaska R.
1304 Mississippi R.
1305 Rideau R.
1306 S. Nation R.

Purpose

1 irrigation
2 commercial
3 industrial
4 municipal
5 public supply
6 recreation
7 construction
~~8 other~~ -dry-use

Status

1 new
2 renewed
3 MOE
4 cancel
5 temporary
6 no permit (P-9000)
7 other

CONVERSION FACTORS

VOLUME	1 Imp. gal.	0.004 5 cq.m
	1 acre ft.	1 233.482 cq.m
FLOW	1 cu. in./min.	0.273 1 cq.cm/s
	1 million Imp.gal./day	0.052 6 cq.m/s
VELOCITY	1 ft./sec.	0.304 8 m/s
	1 ft./min.	0.005 1 m/s

4113 Admaston
3704 Adolphustown
5306 Airy
4802 Alexandria
4709 Alfred/Township
4704 Alfred/Village
4114 Algoma North
4115 Algoma South
4116 Alice & Fraser
4502 Almonte
3504 Ameliasburgh
3705 Amherst Island
4101 Arnprior
4405 Athens
3505 Athol
4410 Augusta
4117 Bagot & Blythfield
3604 Bancroft
3611 Bangor, Wicklow & McClure
3802 Barrie
4105 Barry's Bay
4411 Bastard & South Burgess
3702 Bath
4506 Bathurst
4106 Beachburg
4507 Beckwith
3803 Bedford
3601 Belleville
3502 Bloomfield
4107 Braeside
4401 Brockville
4118 Bromley
4119 Brougham
4120 Brudenell & Lyndoch
4508 Burgess North
4710 Caledonia
4711 Cambridge
3703 Camden East
4406 Cardinal
4503 Carleton Place
4610 Carleton West
3612 Carlow
4705 Casselman
4108 Chalk River
4810 Charlottenburgh
4803 Chesterville
4712 Clarence
3804 Clarendon & Miller
4109 Cobden
4801 Cornwall/City
4811 Cornwall/Township
4412 Crosby North
4413 Crosby South
4606 Cumberland

4510 Darling
4102 Deep River
3605 Deloro
3707 Denbigh, Abinger & Ashby
3603 Deseronto
5391 Dickens
4511 Drummond
3613 Dungannon
4414 Edwardsburgh
4110 Eganville
4415 Elizabethtown
4512 Elmsley North
4416 Elmsley South
3614 Elzevir & Grimsthorpe
3708 Ernestown
4417 Escott, Front of
3615 Faraday
4812 Finch/Township
4804 Finch/Village
3606 Frankford
3709 Fredericksburgh, North
3710 Fredericksburgh, South
4402 Gananoque
4607 Gloucester
4608 Goulbourn
4418 Gower, South
4121 Grattan
4122 Griffith & Matawatchan
4123 Hagarty & Richards
3506 Hallowell
4701 Hawkesbury
4714 Hawkesbury, East
4715 Hawkesbury, West
4124 Head, Clara & Maria
3616 Herschel
3507 Hillier
3805 Hinchinbrooke
4125 Horton
3806 Howe Island
3617 Hungerford
3618 Huntingdon
4805 Iroquois
3711 Kaladar, Anglesea & Effingham
4603 Kanata
4404 Kemptville
3807 Kennebec
4813 Kenyon
4111 Killaloe Station
3801 Kingston/City
3808 Kingston/Township
4419 Kitley
4706 L'Orignal
4513 Lanark/Township
4505 Lanark/Village

4814 Lancaster/Township
4806 Lancaster/Village
4514 Lavant, Dalhousie & Sherbrooke
4420 Leeds & Lansdowne, Front of
4421 Leeds & Lansdowne, Rear of
3619 Limerick
4815 Lochiel
4716 ~~Longueuil~~
3809 Loughborough
5392 Lyell
3620 Madoc/Township
3607 Madoc/Village
3608 Marmora Village
3621 Marmora & Lake
3508 Marysburgh, North
3509 Marysburgh, South
4816 Matilda
4807 Maxville
3622 Mayo
4126 McNab
4407 Merrickville
4515 Montague
3623 Monteagle
4808 Morrisburg
4817 Mountain
5393 Murchison
3125 Murray
3701 Napanee
4613 Nepean
4426 Newboro
3706 Newburgh
3810 Olden
4614 Osgoode
4818 Osnabruck
3811 Oso
4602 Ottawa
4422 Oxford-on-Rideau
4516 Pakenham
3812 Palmerston & N. & S. Canonto
4103 Pembroke/Town
4127 Pembroke/Township
4504 Perth
4128 Petawawa/Township
4112 Petawawa/Village
3501 Picton
3813 Pittsburgh
4707 Plantagenet
4717 Plantagenet, North
4718 Plantagenet, South
3814 Portland
4403 Prescott
4129 Radcliffe
4130 Raglan
4517 Ramsay

3624 Rawdon
4104 Renfrew
3712 Richmond
4612 Rideau
4605 Rockcliffe Park
4702 Rockland
4131 Rolph, Buchanan, Wylie & McKay
4819 Roxborough
4132 Ross
4719 Russell
4133 Sebastopol
5394 Sabine
3713 Sheffield
4518 Sherbrooke, South
4134 Sherwood, Jones & Burns
3625 Sidney
4501 Smiths Falls
3510 Sophiasburgh
4708 St. Isidore de Prescott
4135 Stafford
3609 Stirling
3815 Storrington
3626 Thurlow
3602 Trenton
3627 Tudor & Cashel
3610 Tweed
3628 Tyendinaga
4604 Vanier
4703 Vankleek Hill
3503 Wellington
4136 Westmeath
4409 Westport
4137 Wilberforce
4820 Williamsburg
4821 Winchester/Township
4809 Winchester/Village
3816 Wolfe Island
4423 Wolford
3629 Wollaston
4425 Yonge & Escott, Rear of
4424 Yonge, Front of

County Codes

31 Northumberland
35 Prince Edward
36 Hastings
37 Lennox & Addington
38 Frontenac
41 Renfrew
44 Leeds & Grenville
45 Lanark
46 RMOC (4600 for Task Logging)
47 Prescott & Russell
48 Stormont Dundas & Glengarry
53 Nipissing

SAMPLE

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Sep 19, 1991                         PTTW Report by TWSP Code                           Page:  1

Active Permits Report for TWSP Code:   4516

                                                Issued/
               S P                              Renewed/          Lot/        Basin/
Permit ID      T U Address                      Expired     TWSP  Concession  Name                       Xref
-------------------------------------------- ----------  ----  ----------  -------------------------  -----

88-P-4021 1 1 MR. PAUL RALPH                   07/07/1988  4516  LOT 8       1303                       70078
              CEDAR HILL BERRY FARM                               CONC 7     INDIAN CREEK
              RR #1  PAKENHAM  KOA 2X0          07/31/1993

              2-S       240 GPM     42200 GPD
              1-S       700 GPM    126000 GPD

79-P-4027 1 3 W.L.EDMONDSON                    08/31/1979  4516  9,7
              RR/1 PAKENHAM                                                   INDIAN CREEK
              KOA 2X0                           03/31/1989

              1-S        37 MPM     54000 MPD

84-P-4027 1 6 MOUNT PAKENHAM LTD,              02/07/1985  4516  13,9        1304                       70277
              BOX 190,PAKENHAM,ONT                                          TRIB TO MISSISSIPPI
              KOA 2X0,MR.J.CLIFFORD             01/31/1994

              1-S       200 GPM    288000 GPD
```

see code sheet attached.

see Twpcode list attached.

Taking S = surface water
g = groundwater

Please note Permit Legislation came into effect in 1961. If a taking was initiated prior to 1961 it does not require a Permit. Permits are required for takings in excess of 50,000 L/da

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                                PTTW Report by TWSP Code
                              ----------------------------

Active Permits Report for TWSP Code:   4516

                                                 Issued/
                                                 Renewed/        Lot/       Basin/
            S P                                  Expired   TWSP Concession  Name                       Xref
Permit ID   T U Address
--------- - - ---------------------------------- ---------- ---- ---------- ------------------------ -----

                                                 07/07/1988 4516 LOT 8      1303                     70078
88-P-4021 1 1 MR. PAUL RALPH                                        CONC 7  INDIAN CREEK
              CEDAR HILL BERRY FARM
              RR #1  PAKENHAM  KOA 2X0           07/31/1993

              2-S       240 GPM     42200 GPD
              1-S       700 GPM    126000 GPD
                                                 08/31/1979 4516  9, 7
79-P-4027 1 3 W.L.EDMONDSON                                                 INDIAN CREEK
              RR#1 PAKENHAM
              KOA 2X0                            03/31/1989

              1-S        37 MPM     54000 MPD
                                                 02/07/1985 4516 13, 9      1304                     70277
84-P-4027 1 6 MOUNT PAKENHAM LTD,                                           TRIB TO MISSISSIPPI
              BOX 190,PAKENHAM,ONT
              KOA 2X0,MR.J.CLIFFORD              01/31/1994

              1-S       200 GPM    288000 GPD
```

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Active Permits Report for TWSP Code:   4126

                                                    Issued/
             S P                                    Renewed/         Lot/       Basin/
Permit ID    T U Address                            Expired    TWSP  Concession Name                    Xref
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91-P-4005 1 1 MOUNTAIN CREEK GOLF COURSE           03/26/1991 4126 6          1303                     19104
              C/O PATRICK MULDOON                                   7          MADAWASKA RIVER
              R.R. # 1 ARNPRIOR                    03/31/1996
              K7S 3G7

              1-S                  50000 GPD

87-P-4121 1 2 A.M. STEWART, WABA CK. HYDRO POWER  03/07/1988 4126 2          1303                     51633
              RR #3 ARNPRIOR                                        5          WABA CK
              K7S 3G9                              05/04/1993

              1-S        210 LPM     302400 LPM

89-P-4004 1 2 P. MCKAY                             11/16/1989 4126 7          1303                     70300
              178 SEYMOUR ST., ARNPRIOR                             3          DOCHART CREEK
              K7S 1R5                              11/30/1994

              1-S     100000 LPM  144000000 LPD

85-P-9013 7 8 MR D LINDSAY                                    4126 5          1301                      5444
              WHITE LAKE, ONTARIO                                   9          WELL #5507785
              KOA 3L0


88-P-4011 1 8 Mr. G. Barrie                        05/30/1988 4126 Lot 2      1300                     51647
              P.O. BOX 165                                          Conc 6     WABA CK
              ARNPRIOR ONT K7S 3H4                 05/30/1993

              1-S     192000 LPM   27648000 LPD
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Sep 19, 1991                    PTTW Report by TWSP Code                                    Page:  1
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Active Permits Report for TWSP Code:   4517
                                                      Issued/
                                                      Renewed/           Lot/       Basin/
           S P                                        Expired      TWSP  Concession Name                        Xref
Permit ID  T U Address                                ----------   ----  ---------- --------------------------  -----
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64-P- 349  7 1 MISSISSIPPI GOLF CLUB LTD              03/24/1986   4517  2          1304                        5687
               RR#3  ALMONTE                                             4          MISSISSIPPI RIVER
               ONTARIO                                03/31/1991

               1-S          600 GPM      350000 GPD
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Active Permits Report for TWSP Code:   4507

                                                   Issued/
            S P                                    Renewed/        Lot/       Basin/
Permit ID   T U Address                            Expired    TWSP Concession Name                       Xref
---------   - - ---------------------------------- ---------- ---- ---------- -------------------------- -----

87-P-4097   2 5 MISSISSIPPI LAKE CAMPING           10/19/1987 4507 10         1304                       51224
                RR 1                                               12         2 WELLS
                CARLETON PLACE K7C 3P1             10/02/1997

                1-G         39 GPM       56160 GPD
                2-G         39 GPM       56160 GPD

88-P-4036   5 7 SMITH CONST CO ARNPRIOR LTD        06/17/1988 4507 LOT 11     1305                       70008
                BOX 218,276 MADAWASKA BVD                          CONC 4     TRIBUTARY TO JOCK RIVER
                ARNPRIOR   ONT   K7S 3H4           10/31/1988

                1-S         100 GPM      10000 GPD

88-P-4068   1 8 DOCK'S UNLTD MILLER PROJECT        09/28/1988 4507 LOTS 2 & 3 1304                       70155
                RR#3                                               CONC 12    DOWDALL CREEK
                KINGSTON  K7L 4V2                  09/30/1993

                1-S      22400 GPM
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Active Permits Report for TWSP Code:   4423

                                                    Issued/
          S P                                       Renewed/          Lot/       Basin/
Permit ID T U Address                               Expired     TWSP Concession Name                         Xref
--------- - - ------------------------------------- ----------- ---- ---------- ---------------------------- -----

78-P-4003 1 1 H WILLOUGHBY                          03/06/1978  4423 29, 30
                RR#4 SMITHS FALL ONT                                      B,C   RIDEAU RIVER
                CON B+C                             03/31/1988

                1-S       3500 GPM   1000000 GPD
88-P-4073 2 1 DOROTHY WILLOUGHY                     09/27/1988  4423 29 30      1305                         70201
                P.O. BOX 413                                          B         RIDEAU RIVER
                SMITH FALLS  K7A 4T4                09/30/1993

                1-S       2500 GPM    900000 GPD
90-P-4071 1 7 MR. R.D. SKELLY                       11/05/1990  4423 23         1305
                MEYKNECHT-LISCHER CON.LTD                             B         RIDEAU CANAL/KILMARNOCK
                119 WALGREEN ROAD                   04/30/1991
                CARP, ONT. KOA 1LO

                1-S        750 GPM   1080000 GPD
85-P-4043 1 8 DUCKS UNLIMITED CANADA                08/16/1985  4423  7         1305
                RR#3 KINGSTON ONT                                     1         DALES CREEK
                K7L 4V2                             08/16/1990

                1-S                    23767 GPD
86-P-4064 1 8 DUCKS UNLIMITED CANADA                10/03/1986  4423 12,13      1305                          5783
                RR#3 KINGSTON, ONTARIO                                2         DALES CREEK
                K7L 4V2                             03/31/1991

                1-S       9866 GPM
89-P-4019 1 8 HOWARD CAMPBELL & SONS LTD.           04/05/1989  4423 29                                       70446
                P.O. BOX 30 69 MAIN ST                                1         TACKABERRY'S QUARRY
                LYN   KOE 1N0                       04/30/1994

                1-G      50000 GPS
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Sep 19, 1991                          PTTW Report by TWSP Code                                    Page:  1
                                      ------------------------

Active Permits Report for TWSP Code:   4422

                                                    Issued/
              S P                                   Renewed/        Lot/       Basin/
Permit ID     T U Address                           Expired    TWSP Concession Name                     Xref
---------     - - --------------------------------- ---------- ---- ---------- ------------------------ -----

82-P-4032     1 1 MINISTRY OF NATURAL               08/27/1982 4422 27, 28
                  RESOURCES, CONCESSION RD.                          1,2       KEMPTVILLE CREEK
                  KEMPTVILLE, ONT                   03/31/1992

                  1-S      2720 GPM    1300000 GPD

90-P-4016     1 6 DUCK'S UNLIMITED                  05/31/1990 4422 23-24      1305                     16768
                  R. R. #3                                           5         UNNMD TRIB KEMPTVLE CREEK
                  KINGSTON, ONTARIO                 05/31/1995
                  K7L 4V2

                  1-S     46600 GPM

87-P-4055     1 8 DUCKS UNLTD/S.NATION R. TRIBUTARY 08/06/1987 4422 25         1305                     51301
                  R.R. 3                                             10
                  KINGSTON   K7L 4V2                07/31/1992

                  1-S                  30837050 LPD
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Sep 19, 1991

PTTW Report by TWSP Code

Page: 1

Active Permits Report for TWSP Code: 0

Permit ID	S T	P U	Address	Issued/ Renewed/ Expired	TWSP	Lot/ Concession	Basin/ Name	Xref

South Gower.

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Active Permits Report for TWSP Code:   4817

                                                     Issued/
             S P                                     Renewed/        Lot/       Basin/
Permit ID    T U Address                             Expired    TWSP Concession Name                     Xref
---------    - - ----------------------------------- ---------- ---- ---------- ------------------------ -----

80-P-4007    2 1 R. HOBSON                           05/28/1980 4817  2                                  71200
                 RR#3                                                 6         WELL
                 MOUNTAIN ONT KOE 1SO                02/28/2000

                 2-G         50 GPM       8640 GPD
                 1-S        400 GPM      96000 GPD

84-P-4016    1 1 M. CW. HOWSE                        06/12/1984 4817 21         1306
                 RR# 2                                                8         WELL
                 MOUNTAIN, ONT  KOE 1SO              06/12/1994

                 2-G         12 GPM      17280 GPD
                 1-G         12 GPM      17280 GPD

88-P-4089    3 4 VILLAGE OF WINCHESTER C/O D. BLACK  10/31/1988 4817 20                                  51860
                 547 ST LAWRENCE ST                                   7         WELL # 6
                 WINCHESTER KOC 2KO                  07/31/1993

                 1-G        150 GPM     216000 GPD

84-P-9001    5 5 VILLAGE OF WINCHESTER               12/11/1984 4817 20         1306
                 BOX 484 WINCHESTER,ONT.                              7         WELL
                                                     01/31/1985

                 1-G        100 GPM
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Sep 19, 1991                      PTTW Report by TWSP Code
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Active Permits Report for TWSP Code:   4821

                                                 Issued/
          S P                                    Renewed/        Lot/       Basin/
Permit ID T U Address                            Expired    TWSP Concession Name                      Xref
--------- - - ---------------------------------- ---------- ---- ---------- ------------------------- -----
                                                                                                      70706
89-P-4043 1 2 DENIS ST. PIERRE                   06/26/1989 4821 14
              RR#2 WINCHESTER                                    9          DUG OUT POND/WELL
              KOC 2KO                            06/30/1994

              2-G        1000 GPM    100000 GPD
              1-G        1000 GPM    100000 GPD

81-P-4045 2 3 WINCHESTER CHEESE INC.             10/28/1981 4821 3
              J. M. SCHNEIDER INC.               02/25/1991      5          2 WELLS
              P.O. BOX 490                       02/28/2001
              WINCHESTER KOC 2KO

              2-G           8 GPM     11520 GPD
              1-G          30 GPM     14400 GPD
                                                                                                      20455
91-P-4046 1 3 PETER MONAST                       09/10/1991 4821 12
              BOX 183                                            5          1 WELL SUPPLY NESTLE
              CHESTERVILLE                       04/30/1992
              KOC 1HO

              1-G          60 GPM     80000 GPD

85-P-4030 3 4 VILLAGE OF WINCHESTER              07/29/1985 4821 20         1306                      5086
              BOX 489                                            7          WELL # 6
              WINCHESTER ONT KOC 2KO             07/31/1987

              1-G         150 GPM

86-P-4015 3 4 VILLAGE OF WINCHESTER              03/12/1986 4821 1          1306                      5626
              547 ST LAWRENCE STR                                7          WELL #5
              WINCHESTER ONTARIO                 03/12/1996

              1-G          85 GPM    122400 GPD

84-P-4019 1 5 VILLAGE OF WINCHESTER              11/30/1984 4821 20         1306
              BOX 489                                            7          1 WELL
              WINCHESTER, ONTARIO                11/30/1990

              1-G         125 GPM    180000 GPD
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Active Permits Report for TWSP Code:  4809

                                                     Issued/
           S P                                       Renewed/         Lot/       Basin/
Permit ID  T U Address                               Expired    TWSP  Concession Name                       Xref
---------  - - ------------------------------------ ---------- ----  ---------- -------------------------- -----

73-P- 452  3 4 VILLAGE OF WINCHESTER                09/18/1973 4809  1          1306
               C/O M.O.E.                                             6          WELL #4
               133 DALTON AVE.                      03/31/1983

               1-G         80 GPM    115200 GPD

89-P-4049  2 4 VILLAGE OF WINCHESTER                06/12/1989 4809  1                                     51859
               547 ST.LAWRENCE ST.                                    6          WELL #4
               WINCHESTER KOC 2KO                   06/30/1999

               1-G         35 GPM     50400 GPD

88-P-4090  3 5 VILLAGE OF WINCHESTER WELL # 1       10/04/1988 4809  ST LAW.
               DOUGLAS BLACK                                          STREET     WELL
               547 ST.LAWRENCE ST.KOC2KO            07/31/1993

               1-G        125 GPM    180000 GPD
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Sep 19, 1991                           PTTW Report by TWSP Code
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Active Permits Report for TWSP Code:   4719

                                                   Issued/
           S P                                     Renewed/         Lot/       Basin/
Permit ID  T U Address                             Expired    TWSP  Concession Name                       Xref
---------  - - ------------------------------      ---------- ----  ---------- -------------------------- -----

87-P-4100  1 4 TOWNSHIP OF RUSSELL                 03/11/1987 4719  7,8        1301                       51387
               P.O BOX 570, EMBRUN                                  1          2 WELLS
               KOA 1W0                             02/10/1992

               1-G        820 LPM    1180800 LPD
               2-G       1135 LPM    1634400 LPD

86-P-4017  2 5 SOUTH NATION RIVER CA               03/25/1986 4719  11         1306                       5617
               BOX 69                              05/17/1991       3          CASTOR RIVER
               BERWICK, ONTARIO                    05/31/1996

               1-S                   2000000 GPD

85-P-4036  1 7 DOMTAR CONST. MATERIALS             08/12/1985 4719  19, 3      1306
               BOX 262 RR#1                                                    QUARRY
               GLOUCESTER ONT K1G 3N4              08/12/1995

               1-G        800 LPM    1152000 LPD
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Active Permits Report for TWSP Code:   4711

                                                       Issued/
           S P                                         Renewed/         Lot/       Basin/
Permit ID  T U Address                                 Expired    TWSP  Concession Name                      Iref
---------  - - -------------------------------------- ---------- ----  ---------- ------------------------- -----

89-P-4011  1 1 HERMAN ANTIONETTE AKKERMANS             04/05/1989 4711  16-21      1306                      70379
               R.R. # 4 CASSELMAN                                            7      SOUTH NATION RIVER
               K0A 1M0                                 04/30/1994

               1-S        500 GPM     360000 GPD

86-P-4038  2 2 G W LAPLANTE                            07/09/1986 4711  10         1306                       5598
               P.O. BOX 469                            08/13/1991        6          SOUTH NATION RIVER
               CASSELMAN ONTARIO                       08/30/1996
               K0A 1M0

               2-S        378 GPM     544320 GPD
               1-S      13335 GPM   19202400 GPD

85-P-4018  5 7 DIBBLEE CONSTRUCTION LTD                07/04/1985 4711  29, 5      1306
               BOX4503,STN"E",OTTAWA                                               LAPALME QUARRY
               K1S 5A8,TWP;CAMBRIDGE                   11/30/1985

               1-G                     11000 GPD

88-P-4050  5 7 CORNWALL GRAVEL CO LTD,MR D TINKESS     06/29/1988 4711  LOT 12     1306                      70060
               390 11TH STREET WEST                                     CONC 6 & 7 SOUTH NATION RIVER
               CORNWALL   ONT   K6H 5R9                09/30/1988

               1-S         50 GPM      30000 GPD
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Sep 19, 1991                          PTTW Report by TWSP Code
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Active Permits Report for TWSP Code:  4712

                                                   Issued/
            S P                                    Renewed/          Lot/       Basin/
Permit ID   T U Address                            Expired    TWSP  Concession  Name                    Xref
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75-P-4014   3 4  MOE VILLAGE OF BOURGET            09/08/1975 4712  18          1306                    51230
                133 DALTON ST                                         5         1 WELL
                KINGSTON ONT                       03/31/1985

                1-G        60 GPM     86400 GPD

79-P-4022   3 4 ROCKLAND WATER TRMT PLANT          08/06/1979 4712  27, 1       1301                    51261
                125 EDWARD ST BOX 1150                                          OTTAWA RIVER
                ROCKLAND ONT KOA 3A0               03/31/1989

                1-S        9000 LPM   9100000 LPD

                                                              4712  10                                  19324
91-P-4047   1 4 TWP OF CLARENCE                                       4,5       1 WELL 1 STANDBY WELL
                415 LEMAY STREET
                BOX 70 CLARENCE CREEK
                K01 1N0

                1-G        342 LPM    216000 LPD
                2-G        342 LPM    216000 LPD

                                                              4712  12          1301                    5440
85-P-9019   7 8 MR J NOLAN                                            10        WELL # 5603034
                HAMMOND, ONTARIO
                KOA 2A0


90-P-4026   1 8 NU-EAST DEVELOPMENT CORPORATION    06/27/1990 4712  2           1301                    17150
                P.O. BOX 707                                          11        BECKETT'S CREEK
                ROCKLAND                           06/30/1995
                K4K 1L4

                1-S        31350      4700000
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Active Permits Report for TWSP Code:  4614

                                                      Issued/
             S P                                      Renewed/         Lot/       Basin/
Permit ID    T U Address                              Expired     TWSP Concession Name                      Iref
---------    - - ------------------------------------ ----------  ---- ---------- ------------------------- -----

78-P-4007    1 1 F.PATTERSON                          04/03/1978  4614 10, 9
                 RR/2                                                             DUG OUT POND
                 METCALF, ONTARIO                     03/31/1988

                 1-S        375 GPM    225000 GPD

78-P-4048    1 1 F. PATTERSON                         04/17/1979  4614 10, 9
                 RR/2                                                             CASTOR RIVER
                 METCALF ONTARIO                      03/31/1989

                 1-S        3410 LPM     2050 CMD

80-P-4036    1 1 GLEN ACERS FARMS LTD                 07/29/1980  4614
                 PO BOX 282                                                       RIDEAU RIVER
                 MANOTICK ONT KOA 2MO                 03/31/1990

                 1-S        750 GPM    220000 GPD

88-P-4086    2 1 FORD PATTERSON                       10/18/1988  4614 10-11      1306                      70231
                 R R / 1 EDWARDS ONTARIO                                   9      NORTH CASTOR RIVER
                 KOA 1VO                              09/30/1998

                 1-S        1800 UGM   756000 UGD

91-P-4011    1 1 BRUCE SINCLAIR                       05/17/1991  4614 7          1306
                 RR /1                                                     9      NORTH CASTOR RIVER
                 EDWARDS                              05/31/1996
                 KOA 1VO

                 1-S        250 GPM    360000 GPD

82-P-4015    1 5 TWP OF OSGOODE NON-PROFIT            03/29/1982  4614 28, 1
                 HOUSING AUTHORITY BOX 130                                        WELL
                 METCALF, ONT  KOA 2PO                03/31/1992

                 1-G        35 GPM      15000 GPD

85-P-9009    7 5 ALBION SUN VISTA ESTATES                         4614 1          1305                       5212
                                                                           4      WELL


87-P-4102    2 5 ALBION SUN VISTA TRAILER PARK        12/02/1987  4614 1          1305                      51281
                 BOX 28, RR/2                                              4      3 WELLS
                 GREELY KOA 1ZO                       10/07/1997

                 2-G        30 GPM       3000 GPD
                 1-G        50 GPM      10000 GPM
                 3-G        30 GPM       3000 GPD
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Active Permits Report for TWSP Code:   4614

                                                 Issued/
          S P                                    Renewed/      Lot/       Basin/
Permit ID T U Address                            Expired     TWSP Concession Name                      Xref
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84-P-4012 5 7 TRANSCANADA PIPELINES LTD          05/21/1984  4614 37, 9      1306
              P.O. BOX 54, COMMERCE                                          S. CASTOR RIVER
              COURT WEST, TORONTO ONT            09/30/1984

              1-S       7000 LPM    120230 LPD

84-P-4023 5 7 OTTAWA GAS                         11/28/1984  4614  1, 1      1305
              400 COVENTRY RD.                                               RIDEAU RIVER
              OTTAWA, ONT  K1K 2C7               11/28/1985

              1-S        150 LPM       300 LPD

91-P-4033 5 7 DESCHENES STRUCTURES (EASTERN) INC 07/26/1991  4614            1306                      20023
              P.O. BOX 4338 STATION E                                        GREY'S CREEK
              OTTAWA                             10/30/1991
              K1S 5B3

              1-S        100 IGM     72000 1GD

83-P-4025 1 8 DUCKS UNLIMITED                    11/25/1983  4614 38, 2
              840 WOODBINE RD                                     39, 2
              KINGSTON ONT                       03/31/1993

              1-S     111210 GPM

89-P-4063 5 8 TRANS CANADA Pipe Lines            07/21/1989  4614 3          1306                      70744
              BOX 54 COMMERCE COURT W.                            7,8        S. NATION & N CASTOR RIV.
              TORONTO, ONT. M5L 1C2              09/30/1989

              2-S      14000 LPM   2265000 LPD
              1-S      14000 LPM   2265000 LPD
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Active Permits Report for TWSP Code:   4607

                                                    Issued/
            S P                                     Renewed/         Lot/       Basin/
Permit ID   T U Address                             Expired     TWSP Concession Name                      Xref
---------- - - ---------------------------------- ---------- ---- ---------- ------------------------- -----

88-P-4077 1 2 MR R. CHEVRIER PERMANENT CONCRETE  01/06/1989  4607 28                                   70158
              LAFARGE CANADA INC                                  6         QUARRY DEWATERING
              P.O. BOX 190 BROCKVILLE            12/31/1993

              1-G        500 GPM     700000 GPD

73-P- 349 2 3 DIBBLEE CONSTR LTM.                01/23/1984  4607 25, 5
              P.O. BOX 4503 STATION E                                       QUARRY
              OTTAWA ONT                         03/31/1994

              1-S        354 GPM     509800 GPD

88-P-4093 1 4 MR T.J. DAVIS MANAGER DESIGN CONST 12/21/1988  4607 3                                    51839
              RMOC 495 RICHMOND ROAD                              LONG IS   HILLSIDE GARDENS SUBDIVIS
              7TH FLOOR OTTAWA K2A 4B2           12/31/1998

              1-G        520 LPM     749000 LPD

73-P- 509 2 5 RIDEAU CARLETON RACEWAY            02/20/1984  4607 23, 4     1305
              P.O. BOX 904, RR# 5                                           WELL
              OTTAWA, ONTARIO                    03/01/1994

              1-G        100 GPM      30000 GPD
              2-S        175 GPM      31500 GPD

79-P-4024 1 7 BERTRAND & FREVE CONSTR            08/16/1979  4607 27, 5
              CO. LTD                                                       QUARRY
              1755 WOODWARD DR OTTAWA            03/31/1989

              1-S         14 LPM    1217000 LPD

85-P-9014 7 8 TENSFEN CONSTRUCTION                           4607 14        1305                       5445
              RR#2                                                          WELL # 1519723
              OXFORD STAT. ONT K0G 1T0


86-P-4060 2 8 CUMMING COCKBURN + ASSOC/MINTO CONT 10/21/1986 4607 6,7                                  7043
              1735 COURTWOOD CRES                05/17/1991       2
              OTTAWA, ONTARIO   K2C 2B4          05/31/1996
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Active Permits Report for TWSP Code:   4612

                                                   Issued/
            S P                                    Renewed/        Lot/       Basin/
Permit ID   T U Address                            Expired    TWSP Concession Name                     Xref
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78-P-4039 1 1 J.R. QUINN                           09/18/1978 4612  6, 2
              RR# 3                                                          POND
              NORTH GOWER, ONT KOA 2T0             03/31/1988

              1-S        327 LPM    1170000 LPD

80-P-4035 1 1 MANDERLY TURF FARMS LTD              07/22/1980 4612 41 42                                   71184
              RR#3 N GOWER ONT KOA 2T0                              B.F.     POND
                                                   03/31/1995

              1-S       1000 GPM     360000 GPD

88-P-4060 2 1 MR S. A. HOPE MADERLY SOD            08/22/1988 4612 41        1305                          70142
              R.R. # 3 NORTH GOWER                                  2        RIDEAU RIVER
              ONTARIO KOA 2T0                      08/31/1998

              1-S        940 GPM     676800 GPD

82-P-4014 1 5 RIDEAU TWP NON-PROFIT -              03/29/1982 4612  3,
              HOUSING INC  BOX 310                                           WELL
              NORTH GOWER ONT  KOA 2T0             03/31/1992

              1-G         60 GPM      15000 GPD

90-P-4004 1 5 RMOC  ENVIRONMENTAL SERVICES DEPT    02/26/1990 4612                                         71272
              WATER DIVISION                                                 2 WELLS HILLSIDE GARDENS
              111 LISGAR STREET                    02/28/2000
              OTTAWA K2P 2L7

              1-G                    629000 LPD

68-P-   4 2 6 MRS. J. MONTABONE                    06/27/1980 4612  5                                      71235
              BOX 224                                                1       MUD CREEK
              MANOTICK, ONT  KOA 2N0               02/28/1995

              1-S

90-P-4059 1 7 W.D. LAFLAMME LIMITED                09/28/1990 4612           1304
              P.O. BOX 446, STATION 'A'                                      RIDEAU R./BECKETT LANDING
              OTTAWA, ONTARIO                      01/30/1991
              KOA 3G0

              1-S       1000 GPM    1000000 GPD

83-P-4012 1 8 DUCKS UNLIMITED CANADA               10/31/1983 4612 PRT 17                                  51512
              840 WOODBINE RD                                       5        TRIB TO STEVENS CR.
              KINGSTON ONT                         03/31/1993

              1-S     77130 GPM
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Active Permits Report for TWSP Code:   4612

                                                   Issued/
          S P                                      Renewed/        Lot/       Basin/
Permit ID T U Address                              Expired    TWSP Concession Name                     Xref
--------- - - ------------------------------------ ---------- ---- ---------- ------------------------ -----

85-P-4023 1 8 DUCKS UNLIMITED CANADA               07/19/1985 4612 23, 2      1305
              RR/3 KINGSTON ONT                                    24, 3      LOWER BRASSILS CK
              K7L 4V2                              07/16/1990

              1-S                      434080 GPD

85-P-4058 1 8 DUCKS UNLIMITED CANADA               10/16/1985 4612   , 3      1305
              RR/3 KINGSTON ONT                                      , 4      STEVEN CREEK
              LOTS 19,20,21,                       10/18/1990

              1-S                       42600 GPD

87-P-4118 1 8 DUCKS UNLTD (OOGH PROJECT)           12/21/1987 4612 11 12      1106                     51539
              RR/3                                                 3          HEADWATERS CRANBERRY CK
              KINGSTON K7L 4V2                     12/15/1992

              1-S                       20630 GPD
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Active Permits Report for TWSP Code:   4610

                                                 Issued/
          S P                                    Renewed/         Lot/       Basin/
Permit ID T U Address                            Expired     TWSP Concession Name                     Xref
--------- - - ---------------------------------- ----------  ---- ---------- ------------------------ -----

83-P-4009 1 1 DR. R.M. ARMITAGE                  10/28/1983  4610  4, 8
              DUNROBIA KOA ITO                                               DUGOUT POND
                                                 03/31/1993


90-P-4073 1 1 R.J. NICHOL CONSTRUCTION (1975) LTD 11/23/1990 4610 8          1301
              1755 COURTWOOD CRESCENT                             V          STORMWATER POND-IRRIGATIO
              OTTAWA, ONTARIO                    11/30/1995
              K2C 3J2

              1-S        1000 GPM     600000 GPD
              2-S        6352 GPM    1729160 GPD
              3-S        5411 GPM    1100940 GPD

91-P-4022 1 2 KARSON KARTAGE AND KONSTRUCTION    07/02/1991  4610 1,2                                 19260
              P.O. BOX  264                                       4          QUARRY DEWATERING
              CARP                               06/30/2001
              KOA 1L0

              1-G         400 IGM     576000 IGD

91-P-4027 5 2 WATER AND EARTH SCIENCE ASSOCIATES 07/05/1991  4610 3&4                                 19968
              BOX 430                                             3          OTTAWA LANDFILL
              CARP                               11/30/1991
              KOA 1L0

              1-G         136 LPM     196500 LPD

86-P-4019 2 4 RMOC ENVIRONMENTAL SERVICES        04/07/1986  4610 17         1301                     51280
              WATER DIVISION                                      2          JIULIA [CARTP] WELL
              111 LISGAR STREET                  04/07/1996
              OTTAWA K2P 2L7

              2-2         114 LPM     164000 LPD
              1-G         114 LPM   16400000 LPD

87-P-4060 2 5 FITZROY PROV. PK (RMOC)            08/06/1987  4610 25, 26     1301                     51074
              FITZROY HARBOUR                                     X
              KOA 1B0                            03/31/2000

              1-G          50 GPM      34000 GPD

74-P-4012 2 7 SPRATT SAND AND GRAVEL             02/15/1985  4610  4, 2      4617
              LTD. BOX 150, RR/ 5                                  5,        QUARRY
              OTTAWA, ONT  K1G 3W3               02/15/1995

              1-S        1800 GPM    2592000 GPD
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X

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Active Permits Report for TWSP Code:   4610

                                                           Issued/
          S P                                              Renewed/        Lot/       Basin/
Permit ID T U Address                                      Expired    TWSP Concession Name                         Xref
--------- - - -------------------------------------------- ---------- ---- ---------- ---------------------------- -----

86-P-4052 5 7 ALPHE CYR LIMITED                            08/26/1986 4610            1302                          7022
              336 MOUNTBATTEN AVE                                          4,5        CONSTANCE CREEK
              OTTAWA ONTARIO  K1H 5W3                      12/31/1986


87-P-4088 5 7 SMITHS CONSTRUCTION LTD                      09/07/1987 4610 15         1304                         51412
              BOX 218, 276 MADAWASKA B.                                    4          MISSISSIPPI RIVER
              ARNPRIOR, ONT. K7S 3H4                       10/15/1987

              1-S         60 GPM       15000 GPD

91-P-4038 5 7 MACINNES LTD                                 08/13/1991 4610 21         1304                         20254
              R.R. # 2                                                     6          MISSISSIPPI RIVER
              PERTH ROAD VILLAGE                           08/30/1992
              K0H 2L0

              1-S        750 GPM      360000 GPD

83-P-4019 1 8 DUCKS UNLIMITED                                         4610 16,11
              840 WOODBINE RD                                              17,11      TRIB TO CARP RIVER
              KINGSTON ONT                                 03/31/1993

              1-S     150700 GPM

85-P-9015 7 8 LINDA MANUFACTURING + CONST. CO.                        4610 5          1301                          5446
              CARP, ONTARIO                                                8          WELL # 1519712
              K0A 1L0


85-P-9016 7 8 KARSON KARTAGE CONSTRUCTION                             4610            1301                          5447
                                                                                      WELL


85-P-9017 7 8 PREMIER CONCRETE LTD                                    4610 4          1301                          5448
              1815 BANTREE ST                                              2          WELL # 1519701
              WEST CARLTON, ONTARIO
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Sep 19, 1991                               PTTW Report by TWSP Code                                    Page:  1
                                           ------------------------

Active Permits Report for TWSP Code:   4608

                                                       Issued/
            S P                                        Renewed/          Lot/       Basin/
Permit ID   T U Address                                Expired     TWSP  Concession Name                      Xref
---------   - - ---------------------------------      ----------  ----  ---------- ------------------------  -----

83-P-4002   1 4 TWP OF GOULBOURN  CORP                 02/23/1983  4608  24, 3
                POBOX 189                                                           JOCK RIVER
                STITTSVILLE ONT KOA 3GO                03/31/1993

                1-S       375 GPM     540000 GPD

85-P-4067   1 4 REG MUN OF OTTAWA & CARLETON, WORKS    01/01/1985  4608  11         1305                      5540
                DEPT.,495 RICHMOND RD                                    5          MUNSTER HAMLET #1 WELL
                OTTAWA K2A 4B2 S BONK                  01/01/1995

                1-G       820 LPM    1181000
                2-G       680 LPM     980000 LPD

86-P-4018   2 4 RMOC ENVIRONMENTAL SERVICES DEPT       04/07/1986  4608  A          1305                      51279
                WATER DIVISION                                           3          KINGS PARK WELLS 1&2 RICH
                111 LISGAR ST OTTAWA                   04/07/1996
                K2P 2L7

                1-G        91 LPM   13100000 LPD
                2-G       910 LPM   13100000 LPD
                3-G       910 LPM    1310000 LPD

70-P-   68  1 5 RELOCATABLE HOMES LTD                  07/03/1980  4608  26
                RR# 2 BOX 3                                               11        3 WELLS
                STITTSVILLE, ONT  KOA 3GO              03/31/1990

                2-G        20 GPM      10000 GPD
                1-G        40 GPM      20000 GPD

73-P-  554  2 5 REGIONAL MUNICIPALITY OF               02/13/1984  4608             1305
                OTTAWA-CARLETON, 222                                                WELL
                QUEEN ST., OTTAWA                      03/31/1994

                1-G       150 GPM     216000 GPD

78-P-4046   1 5 CANADIAN OUTDOOR                       01/05/1979  4608   6,11
                TENT & TRAILER PARK                                                 WELL
                28 TOWER RD. OTTAWA ONT                03/31/1989

                1-G        68 LPM      75000 LPD

90-P-4005   1 5 BRADFORD RIVINGTON HOLDINGS INC.       02/26/1990  4608  UNIT 49                              70777
                BOX 1024 MANOTICK                                        I.P. D-21  2 WELLS
                KOA 2NO                                02/28/2000

                1-G       273 LPM     151200 LPD
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Active Permits Report for TWSP Code:   4608

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          S P                                      Renewed/         Lot/       Basin/
Permit ID T U Address                              Expired     TWSP Concession Name                       Xref
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87-P-4062 2 6 THISTLE SPRINGS TROUT FARM           08/06/1987  4608 3          1305                       51238
              R.R. 2                                                5
              ASHTON K0A 1B0                       07/31/1997

              1-G        200 GPM
89-P-4070 5 7 TWONSHIP OF GOULBOURN                08/04/1989  4608            1305                       70560
              C/O A.J.ROBINSON&ASSOC.                               Richmond   JOCK RIVER
              BOX 13130 KANATA,K2K 1X3             09/30/1989

              1-Y        380 GPM      180000 GPD
85-P-9018 7 8 RICHMOND GARDENS LTD                             4608 25         1305                        5448
              RICHMOND, ONTARIO                                     3          WELL / 1519695
              K0A 2Z0


86-P-4067 1 8 DUCKS UNLIMITED CANADA               10/03/1986  4608 3,4,5                                  5801
              RR/3 KINGSTON, ONTARIO                                1          SOURCE AREA KINGS CREEK
              K7L 4V2                              03/31/1991

              1-S                      26458
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Active Permits Report for TWSP Code:   4603

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          S P                                   Renewed/        Lot/       Basin/
Permit ID T U Address                           Expired    TWSP Concession Name                    Xref
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78-P-4045 1 1 CAMPEAU CORP.                     12/13/1978 4603 8, 2
              2932 BASELINE RD.                                            SHIRLEY'S BROOK
              OTTAWA ONT                        03/31/1988

              1-S      4500 LPM   6550000 LPD

84-P-4020 2 1 LOCHMARCH GOLF AND COUNTRY CLUD   10/03/1984 4603 13, 14     1305                    70763
              100 OLD CARP ROAD                                      1     4 DUGOUT PONDS
              KANATA, ONT.  K2K 1X7             07/31/1999

              1-G        39 GPM   1650000 GPD
              2-G      3125 GPM    225000 GPD

88-P-4087 2 1 CAMPEAU CORP                      10/18/1988 4603 8          1301                    70245
              2932 BASELINE ROAD                                2          SHIRLEY'S BROOK
              OTTAWA K2H 8T5                    09/30/1993

              1-S      4500 GPM   6550000 GPD

91-P-4026 1 1 GENSTAR DEVELOPMENT COMPANY       07/04/1991 4603 4                                  18681
              1130 MORRISON DRIVE                               3          WELL NO. 1
              SUITE 260 OTTAWA                  07/30/2001
              K2H 9N6

              1-G       163 GPM    234720 GPD

91-P-4039 1 1 GENSTAR DEVELOPMENT COMPANY       08/13/1991 4603 3                                  16948
              SUITE 260                                         2          IRRIGATION WELL
              1130 MORRISON DRIVE               08/30/2001
              OTTAWA  K2H 9N6

              1-G        64 GPM     91440 GPD

90-P-4025 1 4 TERRACE INVESTMENTS LIMITED       11/05/1990 4603 11         1301
              411-303 MOODIE DRIVE                              V          STORMWATER MANAGE'MT POND
              NEPEAN, ONTARIO                   06/30/1995
              K2H 9C4

              1-S

89-P-4075 1 6 R.W. CONNELLY ASSOCIATES LTD.     09/13/1989 4603 21         1301                    70675
              236 WESTBROOK RD. SITE 6                          1          BEAV.POND DRAIN CONSTAN L
              BOX 3A, CARP, KOA 1L0             09/30/1994

              1-S      1500 LPM  22000000 LPD

85-P-4010 2 8 GENSTAR DEVELOPMENT COMPANY       05/27/1985 4603 6-7, 7     1301                    12414
              1130 MORRISION DRIVE                              3  , 2     TRIB WATTS CK. STORM POND
              SUITE 260 OTTAWA K2H 9N6          05/31/1995

              1-S               158000000 LPD
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Active Permits Report for TWSP Code:   4603

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          S P                                     Renewed/        Lot/       Basin/
Permit ID T U Address                             Expired    TWSP Concession Name                      Xref
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88-P-4001 1 8 KANATA RESEARCH PARK CORP.          01/05/1988 4603 9          1301                      51515
              600 MARCH RD                                        4          SHIRLEY'S BROOK
              KANATA,ONT. K2K2E6                  01/05/1993

              1-S                    904666 GPD
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Active Permits Report for TWSP Code:   4613

                                                  Issued/
          S P                                     Renewed/        Lot/       Basin/
Permit ID T U Address                             Expired    TWSP Concession Name                      Xref
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90-P-4019 1 2 REGIONAL MUNICIPALITY OTTAWA-CARLET 06/06/1990 4613 11                                   11698
              495 RICHMOND ROAD                                   4(R.F.)    POND FOR GW CONTROL
              OTTAWA, ONTARIO                     06/30/2000
              K2A 4B2

              1-G        4500 LPM    6480000 LPD

84-P-4009 2 3 AMBRO CONSTRUCTION LTD.             11/30/0018 4613            1305
              RR# 6                                                          QUARRY
              OTTAWA, ONTARIO                     05/01/1995


86-P-4023 1 4 RMOC - WORKS DEPT - WATER SUPPLY    04/29/1986 4613 10         1305                       5689
              111 LISGAR STREET                                   1 RID. FR. CARLETON LGE WELLS1,2,3&4
              OTTAWA, ONTARIO                     04/29/1996
              K2P 2L7

              1-G         340 LPM   49000000 LPD
              4-G         227 LPM    3270000
              2-G          68 LPM     980000 LPD
              5-G         340 LPM     490000 LPD
              3-G         227 LPM   32700000 LPD

91-P-4040 1 4 CITY OF NEPEAN                      08/13/1991 4613 16,17      1305                      20250
              101 CENTREPOINTE DRIVE                              1          BARRHAVEN CREEK
              NEPEAN                              08/30/1996
              K2G 5K7

              1-S                      68000 CUM

89-P-4002 1 5 CARELTON LODGE                      07/24/1989 4613 10                                   70009
              500 OLD PATRICK ST.                                 1          2 WELLS
              OTTAWA, ONT K1N 9G4                 02/21/1994

              1-G         100 GPM      33500 GPD

86-P-4009 2 6 CITY OF NEPEAN                      02/17/1986 4613 15         1301                       5616
              1701 WOODROFFE AVE                                  1          OTTAWA RIVER
              NEPEAN, ONTARIO  K2G 1W2            02/17/1991

              1-S         500 GPM     720000 GPD

89-P-4034 1 6 CITY OF NEPEAN PARKS & RECREATION   05/04/1989 4613 14         WELL                      70564
              101 CENTREPOINTE DRIVE                              1 (O.F.)   ANDREW HAYDON PARK
              NEPEAN K2G 5K7                      04/30/2000

              1-G         450 GPM     684000 GPD
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Active Permits Report for TWSP Code:   4613

                                                    Issued/
           S P                                      Renewed/         Lot/       Basin/
Permit ID  T U Address                              Expired    TWSP Concession Name                     Xref
---------- - - ----------------------------------- ---------- ---- ---------- ------------------------- -----

84-P-4008 5 7 MCPARLAND CONST. LTD.                            4613            1305
              P.O. BOX 11068 MOODIE DR.
              NEPEAN, ONTARIO                       12/31/1984

              1-S        1350 GPM     275000 GPD
              3-S        1350 GPM     275000 GPD
              2-S        1350 GPM     275000 GPD

88-P-4082 5 7 TAGGART CONST LTD TRAIL ROAD SITE    10/20/1988 4613                                      70059
              3187 ALBION RD SOUTH                                             DUGOUT POND
              OTTAWA K1V 8Y3                        02/28/1989

              1-G         100 GPM      60000 GPD

91-P-4020 5 7 TAGGART CONSTRUCTION LIMITED          06/28/1991 4613 N.SIDE 416                          19791
              3187 ALBION ROAD SOUTH                                ACRES RD   SEWER INSTALLATION
              OTTAWA                                10/30/1991
              K1V 8V3

              2-G         440 USG     633600 USG
              1-G         440 USG     633600 USG
              3-G         440 USG     633600 USG

84-P-4022 2 8 NORTHERN TELECOM CANADA               11/23/1984 4613 11         1305                     70742
              C/O OLIVER, MANGIONE,                                 1          STILLWATER CREEK
              MCCALLA AND ASSOCIATES                07/31/1994

              1-S                     645000 LPD

90-P-4001 5 8 OLIVER MANGIONE AND MCCALLA ASS       01/25/1990 4613 MERIVALE                            71177
              154 COLONNADE ROAD SOUTH                              SUBDIVISIN 3 WELLS
              NEPEAN K2E 7J5                        10/30/1990

              3-G          30 LPM      43200 LPD
              1-G          30 LPM      43200 LPD
              2-G          30 LPM      43200 LPD
```

APPENDIX G
GIS MODELLING FOR THE OUTLINE OF THE BEDROCK AQUIFER GROUNDWATER RECHARGE PROBABILITY MAP

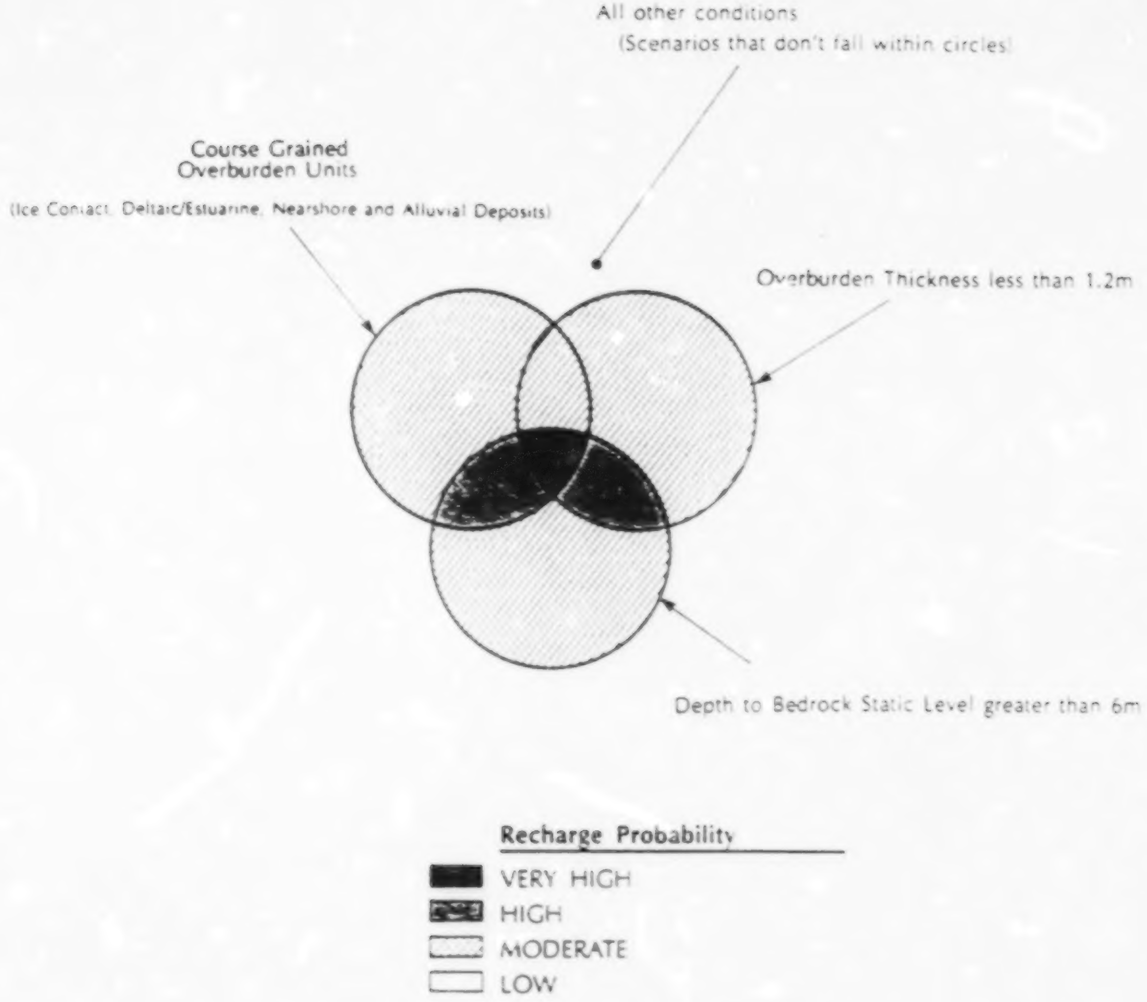

All other conditions
(Scenarios that don't fall within circles)
Course Grained
Overburden Units
(Ice Contact, Deltaic/Estuarine, Nearshore and Alluvial Deposits)
Overburden Thickness less than 1.2m
Depth to Bedrock Static Level greater than 6m
Recharge Probability
VERY HIGH
HIGH
MODERATE
LOW

Figure G-1

Modelling Rationale for Bedrock Aquifer Recharge Zones

GEO-ANALYSIS

Project No. G9105

A GIS model was developed to outline potential recharge zones in the bedrock aquifer. These parameters included:

1) depth to static level in bedrock wells
2) distribution of granular soils
3) distribution of less than 1.2 m of overburden

Four (4) classes were generated (Figure G-1) including:

A) Very high probability for recharge, defined as areas where granular soils less than 1.2 m in thickness have in excess of 6 m of depth to static level.

B) High probability for recharge, defined as the areas where granular soils or shallow soils (i.e. <1.2 m) have a depth to static level in excess of 6 m.

C) Moderate probability for recharge, defined as the areas where only depth to static level is greater than 6 m, or where only soil thickness is less than 1.2 m, or where only granular soils are present, or where granular soil is less than 1.2 m.

D) Low probability for recharge, defined as the areas where depth static level is less than 6 m, where soil thickness is greater than 1.2 m and where no granular soil is present.

APPENDIX H
GIS MODELLING FOR THE OUTLINE OF THE TERRAIN SUITABILITY FOR SEPTIC SYSTEM

A GIS model was developed to outline the terrain suitability for septic systems. Two parameters were used, including the overburden thickness, and the surficial geology. Best suitability is attributed to a terrain which offers best protection to the underlying aquifers.

Four classes were generated:

Class 4 represents:

poor suitability where the overburden was less than 1.2 m in thickness and where geological units consists of wetland and bedrock outcrop

Class 3 represents:

low suitability, where overburden units are more permeable (i.e. granular) including: ice contact deposit, deltaic and estuarine deposit, near shore marine sediments and alluvium.

Class 2 represents:

moderate suitability, where overburden thickness includes all the glacial till as the upper stratigraphic unit, and where it includes the clay soils that are less than 10 m in thickness.

Class 1 represents:

high suitability, where the overburden thickness includes all the marine clay equal to or in excess of 10 m.

APPENDIX I
GIS MODEL FOR THE OUTLINE OF SUITABILITY FOR DEVELOPMENT

A GIS model, using SPANS, was developed and outlines development potential. The parameters included the overburden aquifer map, the bedrock aquifer map, and the terrain suitability for septic system map. A matrix was developed ().

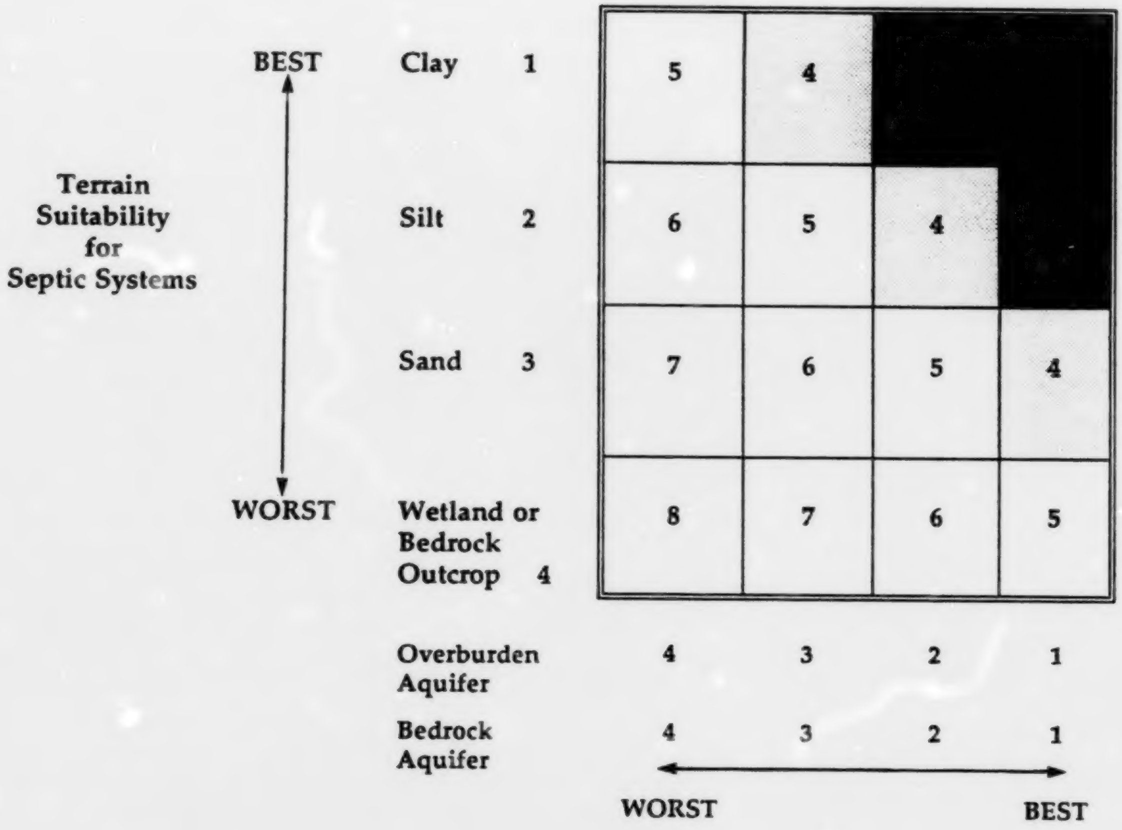
Three classes were generated including high potential, moderate potential, and low potential for development based on private individual services.

High potential class includes either overburden or bedrock aquifer, best and second best groups, and best terrain suitability for septic systems (i.e. less than or equal to 3 points). A total of 23% of the study area is included in this zone.

Moderate potential class includes a combination of second best aquifer with moderate suitability for septic systems or nearby matrix-combination to generate total points equal to 4. A total of 15% of the study area is included in this zone.

Low potential class includes all other areas, ranging from 5 to 8 points. These areas include severe deficiencies in either one parameter (i.e. septic or aquifer) or in both parameters. A total of 62% is included in this zone.

TABLE I-1
SUITABILITY FOR DEVELOPMENT



Terrain Suitability for Septic Systems

BEST	Clay 1	5	4	■	■
	Silt 2	6	5	4	■
	Sand 3	7	6	5	4
WORST	Wetland or Bedrock Outcrop 4	8	7	6	5
	Overburden Aquifer	4	3	2	1
	Bedrock Aquifer	4	3	2	1
		WORST			BEST

DEVELOPMENT POTENTIAL RANKING

■ BEST

▨ MEDIUM

☐ POOR

APPENDIX J

The
REGIONAL
MUNICIPALITY
of WATERLOO

PLANNING AND
DEVELOPMENT DEPT.

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WATERLOO

REGIONAL MUNICIPALITY OF WATERLOO

GUIDELINES

FOR

HYDROGEOLOGICAL STUDIES

FOR

PRIVATELY SERVICED DEVELOPMENTS

Date of Issue: May 1991

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May 1991

REGIONAL MUNICIPALITY OF WATERLOO

GUIDELINES FOR HYDROGEOLOGICAL STUDIES FOR PRIVATE SEWAGE SYSTEMS

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THE REGIONAL MUNICIPALITY OF WATERLOO

GUIDELINES FOR HYDROGEOLOGICAL STUDIES FOR PRIVATE SEWAGE SYSTEMS

1. PURPOSE OF THE GUIDELINES

1.1 The purpose of the Guidelines is to provide developers and their consultants with the minimum information requirements for the preparation of hydrogeological reports in support of developments on private services.

The required information will establish:

1) that an adequate and safe supply of potable water is available for the proposed development;
2) that soil conditions on site are suitable for on site sewage disposal and,
3) that on site sewage disposal will not impair use of the groundwater resource on site or in adjacent areas

It is expected that the Guidelines will result in a faster evaluation of development proposals by ensuring that the necessary information is available at the appropriate time and with a consistent level of information.

2. INTRODUCTION

2.1 Over the last few years the demand for rural residential development has grown substantially. These developments have proceeded with individual or communal wells for water supply and private sewage disposal systems. In many cases the geotechnical and hydrogeological assessment of the sites has been superficial, and water quality issues have been left to the purchaser to address. Assessments often do not appear to recognize that septic effluent may be recharging the water supply aquifer. Recent research into private septic disposal systems has indicated that narrow, elongated, plumes are developed in granular materials and bedrock which could potentially impact local water supplies with nitrate and other contaminants. In order to address the potential public health issue, the Region has developed these guidelines to ensure that all developers address the hydrogeological and geotechnical issues relating to water supply and waste disposal as part of the approval process.

2.2 Developers will be required to submit reports which will address the issues of water supply, water treatment, if required, the impact of septic system effluent on groundwater and surface water and the design of the septic disposal system. These reports will be prepared by a qualified hydrogeologist and where necessary, a professional with experience in the design of septic systems.

2.3 In recognition of the reluctance of developers to invest heavily in hydrogeological and geotechnical investigations early in the planning approval process, the required information will be provided in two stages. Stage 1 will provide preliminary information on the suitability of the site for development on private services. Details of the requirements for Stage 1 are included in the section entitled 'Stage 1 - Preliminary Environmental Evaluation'. The stage 1 assessment will indicate whether or not the site will likely be suitable for the proposed development and if so recommend proceeding to Stage 2, the detailed hydrogeological investigation of the site.

2.4 The Region's preference is to establish communal water supply systems for each new subdivision either by connecting to an existing system or by constructing a new communal system for the proposed development. Use of individual wells will be discouraged.

2.5 The recommendations and conclusions provided in the Stage 1 and Stage 2 reports must be to the satisfaction of the Regional Commissioner of Engineering and the Commissioner of Health Services on the basis of demonstrated technical feasibility.

2.6 These guidelines should be read in conjunction with the 'Design Standards for Small Groundwater Supply Systems, August 1987', and 'Design Standards for Septic Systems' available on request from the Region's Water and Wastewater Operations Division and Environmental Health Services and the MOE "Manual of Policy Procedures and Guidelines for on Site Sewage Systems".

3. THE PLANNING APPROVAL PROCESS

3.1 Introduction

The Planning Approval process has operated for many years under the assumption that all lands are serviceable by private sewage disposal systems designed in accordance with MOE Regulations and Regional Policies. It has also been assumed that water supplies can be made available in appropriate quantities and quality in all locations. Accordingly, private servicing considerations have normally been deferred for investigation until after a commitment to development has been made through Official Plans, Zoning By-law Amendments and the draft approval of Plans of Subdivisions.

Where water supply and private sewage servicing evaluations have subsequently revealed inherent limitations to soil and ground water conditions, the Region, Area Municipalities and development applicants have tended to engage in a "rear guard" action of attempting to mitigate these servicing problems rather than re-evaluating the development commitment itself. The tendency has been to rely on extensive modification to natural soil or the engineering of special water supply facilities to minimize such deficiencies. A full evaluation of alternative location, density or design of development has not usually occurred even where significant natural limitations for private services are found to exist. No consistent monitoring of these engineering solutions has occurred to assess their subsequent performance in servicing systems and their potential to result in groundwater and drinking water contamination. It is now evident that servicing evaluation form a more significant consideration, earlier in the Planning Approval Process.

3.2 Principle of These Guidelines

The intent of the Guidelines is to modify the operation of the Planning Approval process to ensure that the capability of land for private servicing systems in an environmentally safe manner and on a permanent basis, be proven before planning commitments are made. The burden of proof will be shifted to the proponents of new development in the submission of more detailed hydrogeological studies prior to consideration of their proposals for significant planning approvals. No final commitment to development will generally be given until there is conclusive evidence that private servicing systems are viable in the long term without cumulative environmental impacts.

3.3 Policy Considerations

a) Although, as recent evidence suggests, concern should be warranted for all developments on private sewage systems with respect to ground water resources, the practical focus of this concern is on intensive developments typically associated with plans of subdivision, official plan amendments and rezonings. The implications of complex technical requirements for small scale developments are too onerous for most applicants and available staff resources. Therefore, these Guidelines apply to residential developments of five (5) units or greater, or non- residential developments generating effluent greater than 10,000 litres per day.

b) Notwithstanding a) above, smaller scale developments may be subject to the requirements of these guidelines if, in the opinion of the Regional Commissioner of Engineering, they pose a threat to groundwater supplies or other environmental considerations.

c) For areas within Settlement Policy Area A and D of the Regional Official Policies Plan on which private serviced developments are proposed, a Stage 1 Report will not be accepted until an evaluation of full municipal servicing options has been conducted to the satisfaction of the Regional Commissioners of Planning and Development and Engineering. Such evaluation will define the methods and costs by which full services are provided and indicate the land use and density options that will facilitate the provision of full services in the long and short term.

3.4 Specific Application Type

a) Official Plan Amendments

i) A stage 1 evaluation shall be required to be submitted prior to the circulation of the proposed Official Plan Amendment. Sufficient copies of the Stage 1 report will be submitted for review by Regional Departments, the Ministry of the Environment and other Agencies as appropriate. It is recommended that approval of the Stage 1 report be provided before the proposed Official Plan Amendment is adopted by the Area Municipal Council. Circulation of an adopted Official Plan Amendment will not occur until a Stage 1 has been approved by the Regional Commissioner of Engineering.

ii) If, in the opinion of the Regional Commissioner of Engineering a Stage 2 evaluation is appropriate before final approval of the Official Plan Amendment due to inherent limitations for private servicing or potential impact of private servicing systems on the natural environment, submission of the Stage 2 report will be required before the Official Plan Amendment is considered by Regional Council pursuant to its delegated authority under the Planning Act.

iii) Where a Stage 1 evaluation has been approved by the Regional Commissioner of Engineering and the Official Plan Amendment has been approved by Regional Council, the Stage 2 report shall be required prior to the approval of an application for consent, draft approval of a plan of subdivision or third reading of an amendment to the zoning by-law.

b) Plans of Subdivision

i) Where a Stage 1 evaluation has not previously been conducted and the subject lands have already been designated for development by the Area Municipal Official Plan, a Stage 1 study shall be required to be submitted prior to the circulation of a plan of subdivision. Sufficient copies will be provided (as above) to permit review by all appropriate agencies.

ii) Where a Stage 1 report has been approved by the Regional Commissioner of Engineering in the Post Circulation comments, a Stage 2 report must be completed and approved by the Regional Commissioner of Engineering and the Ministry of the Environment prior to Draft Plan Approval. The recommendations of the Stage 2 report will precisely define the conditions of Draft Plan Approval respecting the installation and monitoring of private servicing systems.

c) Zoning By-law Amendments and Consents

i) Where a Stage 1 evaluation has not previously been conducted and the subject lands have already been designated by an Area Municipal Official Plan, a Stage 1 study will be provided upon circulation of the proposed zoning by-law amendment or consent by the Area Municipality (as above) to permit review by all appropriate agencies.

ii) Where a Stage 1 report has been approved by the Regional Commissioner of Engineering in post circulation comments, a Stage 2 report will be completed and approved by the Regional Commissioner of Engineering and the Ministry of the Environment prior to Third Reading of the Zoning By-law Amendment or the stamping of the deeds for consent to be granted.

4.0 STAGE 1 - PRELIMINARY ENVIRONMENTAL EVALUATION

Introduction

4.1 The Stage 1 investigation will involve a review of existing available geologic and hydrogeologic information, a door-to-door well survey, excavation of test pits, measurement of water levels and an estimation of the percolation time of the native soil, in order to determine the suitability of the site for development on individual wells or on a communal water system and private septic systems. A report will be prepared for review by the Regional Municipality of Waterloo and the Ministry of the Environment. The report will provide preliminary recommendations on the potential of the site for development on private services.

The information requirements at Stage 1 are as follows:

Identification Of The Site Location

4.2 Identification of the site location will include the following information:

- lot number and concession
- area municipality
- roads and/or highways bordering the site
- land use designations of the Official Plan and permitted uses in the zoning of the site and, according to the official plan, of the site and lands within 500 metres of the site
- present land use of the site and adjacent lands.

Data Review

4.3 A review of all available geologic and hydrogeologic information shall be conducted prior to conducting the preliminary field program. The data review shall include but not necessarily be limited to the following:

- topographic maps (1:10,000)
- soil and aggregate reports
- quaternary geology maps and reports
- bedrock geology maps
- hydrogeologic or septic suitability reports for adjacent subdivision developments
- Ministry of the Environment water well records
- water supply reports for existing nearby developments
- groundwater quality data
- MOE hydrogeologic files, and
- hydrogeologic maps.

The information obtained from the existing data review should include:

Site Setting

- site topography including surface relief, water courses, ponds, ESPA's etc.;

Physiographic Region

- as described by Chapman and Putnam (1984)

Regional Geology

- overburden thickness and soil types, eg. glaciofluvial, outwash etc., and bedrock type, eg. unit, age etc.

Regional Groundwater System

- overburden and bedrock aquifers, general identifiable units, general characteristics, flow direction, previous exploitation, communal well locations, permitted well locations, existing well yields, recharge and discharge areas etc.

4.4 Stage 1 Field Program

Based on the results of the review of available information, a suitable preliminary field program will be designed and implemented to undertake a preliminary determination of site specific soil and groundwater conditions. The purpose of the Stage 1 Field Programme is to conduct a preliminary assessment of the feasibility of development of the site on private services.

A door-to-door inventory of water supply wells within 1.0 kilometre of the proposed development will be conducted prior to implementing the field program. The survey will be conducted to determine the condition and details of local wells, including the method of construction, water level, pump intake and well depths, water use, general water quality and suitability of the well for future monitoring, if required. The results of this survey will also determine the number of wells located 1.0 kilometer downgradient of the site, and thus the wells which could be potentially impacted by the proposed development.

An on-site investigation comprised of excavation of test pits with a backhoe, or shallow boreholes, will be conducted to determine surficial geologic and hydrogeologic conditions. One test pit is required for every two hectares (five acres) of land to be developed, and a minimum of three test pitsto a minimum depth of 2 metres for each development. Additional test pits must be excavated where complex geologic conditions dictate. Where conditions indicate that the seasonal high water table is within 1.5 meters of the ground surface, a standpipe shall be installed to determine water levels and to collect groundwater samples for chemical analysis. Water levels will be monitored on completion of the installation and on at least one other occasion to determine stabilized water levels. A field survey shall also be conducted, where appropriate, to determine the direction of shallow groundwater flow.

4.5 A minimum of three representative soil samples from the proposed leaching bed, shall be analyzed in the laboratory to determine grain size distribution. An estimate of the percolation time of the native soil will be determined from the results.

4.6 Where appropriate, selected standpipes shall be fully developed prior to sampling. A minimum of three representative groundwater samples will be collected for analysis of nitrate. The chemical results will be utilized for the preliminary nitrate impact assessment to be prepared for the site. If standpipes are not installed on site water samples shall be collected, where possible, from three nearby domestic wells.

Preliminary Nitrate Impact Assessment

4.7 A preliminary nitrate impact assessment is required in order to determine the potential for development of the site, if any, using private sewage disposal systems. Available information and on-site test results will be utilized to estimate potential recharge to the site via infiltration of precipitation and where appropriate, lateral flow Recharge rates shall be scientifically determined, based on the nature of the soils beneath the leaching bed and downgradient areas determined during the test pit programme. The results will be utilized in conjunction with the design sewage flow, to estimate available dilution, where appropriate, and ultimately the potential nitrate level at the downgradient property boundary. The results of research on plume formation should also be incorporated. Emphasis must be given to predicting where nitrate and other contaminants will travel in the long term and their ultimate impact on aquifers, wetlands, streams and lakes. Arguments for other attenuating mechanisms can also be incorporated if adequately supported by scientific research or field monitoring data. All assumptions used in the preliminary nitrate impact assessment must be stated and substantiated.

4.8 From the preliminary on site investigation and nitrate impact assessment an estimate of the number of lots which can be accommodated on the property will be determined. It should be noted that the number of lots proposed during the Preliminary Environmental Evaluation, may ultimately be revised based on the results of the more detailed Hydrogeologic Study required in Stage 2.

Stage 1 Environmental Evaluation Report Requirements

4.9 On completion of evaluation of all existing data and test results, a report will be submitted to the Regional Municipality of Waterloo's Planning Department with the application for planning approval and to other appropriate regulatory authorities for review. The primary purpose of the study is to enable a preliminary determination as to the potential suitability of the site for development on private sewage disposal systems and the availability of a potable water supply.

In addition to the information requirements of paragraphs 4.2 to 4.8, the preliminary environmental evaluation will address, but not be limited to the following:

- background and predicted nitrate levels
- nitrate impact assessment
- assessment of the suitability of the site for development
- based on the preliminary hydrogeological and geotechnical assessment the proposed number of lots

- type of septic system proposed with conceptual design
- preliminary assessment of groundwater quantity and quality
- type of water supply proposed
- options for phased development based on the hydrogeological assessment of the site
- assessment of the impact of existing developments and possible future downgradient developments

4.10 The results of the Preliminary Environmental Evaluation report will be utilized by the Region to determine the potential of the site for development from the perspective of water supply and sewage disposal. If the Stage 1 study concludes the site is potentially suitable for development and regulatory authorities agree, then a detailed Hydrogeologic Study will subsequently be required to substantiate the conclusions of the preliminary assessment report. Should the Region disagree with the conclusions presented in the Stage 1 report, then the developer may request a peer review of the report by a qualified professional of the Region's choosing at the developer's cost.

5 STAGE 2 - DETAILED HYDROGEOLOGICAL EVALUATION

Introduction

5.1 The Stage 2 evaluation will only be undertaken if the Stage 1 report is accepted by the Region and will build on the preliminary information provided in the Stage 1 report. The Stage 2 report will be a complete stand alone document providing detailed geotechnical and hydrogeological information and analysis based on a site investigation. Preparation of the Stage 2 report will require an on site hydrogeological investigation This report will be reviewed by the Region's Planning, Engineering and Health Departments and will be the basis for providing or denying servicing approval. The Stage 2 report will include all information contained in the Stage 1 report, and the following:

Site geology, including overburden characterization and if appropriate bedrock type, unit and formation.

Identification of aquifers and aquitards including depth, thickness, extent, continuity, and hydraulic conductivity. The information will be presented in geologic/hydrogeologic cross-sections. The aquifer proposed for water supply must be identified.

Description of groundwater flow of shallow systems and deep systems, where appropriate including a contour plan showing flow direction, the average horizontal gradient, and determination of vertical gradients between hydrogeological units.

A water balance appraisal including approximate annual precipitation, infiltration rate, recharge from leaching beds, water consumption and groundwater flux.

5.2 The capability of the aquifer to supply a sufficient quantity of water in accordance with the requirements of Regional 'Guidelines for Small Groundwater Supply Systems August 1987' must be demonstrated. The water quality supplied to consumers must meet the Ontario Drinking Water Objectives. Where treatment is required for removal of, for example, iron or manganese, source treatment systems will be required for communal systems.

5.3 Shallow wells will be discouraged due to their susceptibility to contamination. Where possible wells must be developed in deep confined aquifers to provide protection from surface activities. In locations where a protective aquitard does not exist, or it is limited in vertical thickness and extent, the well location must take into consideration potential sources of off-site and on-site contamination such as, septic leaching beds, farming operations, industrial operations etc., recognizing where appropriate the potential formation of plumes from these sources.

Well Capacity

5.4 Proof of existing well or new well capacity to supply the proposed development must be established by conducting a pumping test of sufficient duration (minimum of 24 hours) and analysis to demonstrate the hydraulics of the well and aquifer system. The pumping test must satisfy both the Ministry of the Environment and Regional requirements. The degree to which vertical leakage contributes to the pumped volume must be established.

Geophysical Logs

5.5 Geophysical logs will be provided for all water supply and standby wells.

Water Quality

5.6 The quality of the water must be determined by sampling and testing the proposed water source. Parameters to be tested for must be in accordance with the Ontario

Drinking Water objectives. Current or previous land use practices should be taken into consideration in defining additional parameters such as, herbicides, pesticides etc.

5.7 Irrespective of the aquifer chosen for the water supply, the water quality of the upper shallow aquifer, if applicable, must be determined.

The shallow aquifer assessment will also include the potential impact that the shallow groundwater flow will have on adjacent developments and sensitive areas such as wetlands and water courses.

Septic System Suitability Evaluation

5.8 The evaluation must take into consideration the hydrogeological conditions of the site and groundwater resource evaluation and integrate these with septic effluent disposal issues.

5.9 The septic system study must be consistent with the minimum requirements of the MOE Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems and Regional Health Services Department Guidelines.

5.10 The septic system suitability evaluation will require soils investigations to determine soil profiles and to estimate percolation for each lot times across the site. Soil profiles to a minimum depth of 2 meters are required for each surficial geologic material on the property. The percolation times can be determined by the following methods:

- Grain size analysis of representative soil samples, and/or
- In-situ Percolation tests, and/or
- Guelph permeameter tests

5.11 Any one method can be used to determine percolation times but it is recommended that more than one method be used to provide comparative results. Representative percolation times are required for all soil types on the property. Lot specific testing will be required prior to draft approval for the design of private sewage systems.

5.12 Percolation times will be used to determine the design of the septic system according to the details given by MOE's Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems, and Regional Health Services Department guidelines. All of the limiting factors such as depth to the water table, thickness of acceptable soils, range of percolation times, and distances to wells and surface water, as set out in the MOE and Regional Guidelines must be considered in the design.

5.13 Based on the septic system design and the design sewage flow, the hydraulic loading to the groundwater must be assessed. In determining the hydraulic loading, consideration must be given to the hydraulic properties of the soil materials in which the septic systems will be placed as well as the underlying materials. The loading must be calculated on a lot-by-lot basis as well as in consideration of the development as a whole.

5.14 Using all of the information described above, provide a diagram(s) showing the typical lot plan, building and leaching bed envelopes recommended for each leaching bed design. Each leaching bed must be designed specific to the conditions on each lot.

Assessment of Potential Impact

5.15 The intent of this assessment is for the proponent to demonstrate a degree of understanding and evaluation of site conditions such that the potential impact of the proposed development can be shown. There are two main impacts which must be addressed i) those that concern effects due to exploitation of the groundwater resources and ii) those due to contamination caused by operation of septic systems.

Groundwater Resources

5.16 The proponent should address the following minimum requirements:

- determine potential long term hydraulic impact of groundwater extraction, ie what is the sustainable yield of the well and aquifer.

- address potential for well interference
- identify nearby wells and corresponding aquifer(s),
- assess long term source contributions of groundwater to wells and the effect on groundwater quality (infiltration, leakage, bedrock, surface water), and identify area over which infiltration replenishes the water supply well(s).
- provide data, calculations and interpretations to support conclusions regarding hydraulic impacts.

Septic System

5.17 Operation of a septic tank and leaching bed system introduces sewage effluent to the subsurface. It is intended that the proponent shall demonstrate that the impact of contaminant loading due to septic systems is acceptable. It is recognized through research that typical septic systems may result in long narrow contaminant plumes in permeable overburden and bedrock which contain a varisty of contaminants. Therefore, the applicability of ideal dilution calculations (typically carried out for nitrate) is limited and must be used with caution.

5.18 The proponent may use such calculations to provide a subjective evaluation of the magnitude of potential impact utilizing existing MOE Reasonable Use guidelines. However, such an approach may not be appropriate for assessing impact on individual potential receptors when conditions result in long narrow contaminant plumes in groundwater.

5.19 The proponent should address the following:

- determine potential nitrate loading (or other critical contaminants) on shallow groundwater regime

- assess magnitude of potential impact on a lot by lot basis, as well as the development as a whole
- determine appropriate lot size(s) to provide adequate effluent dilution or attenuation
- identify potential receptors (such as wells, surface water, deep aquifer, future aquifer)
- assess potential impact on identified receptors (including vertical migration to deep aquifer)
- assess long term effects of contaminant loading and cumulative growth.
- land restrictions in the immediate vacintiy of the well
- assess the impact of plumes from leaching beds on the water supply for the development as well as off site water sources. Where individual wells and septic leaching beds are proposed, provide location plans for wells and leaching beds taking into consideration the hydraulic gradient and plume formation.
- assess the potential for and effect of changes in the contaminant migration pathways that may occur as a result of water withdrawals from the aquifer.6.0

MONITORING OF WATER QUALITY

Developers will be required to demonstrate that the impact of previous phases is acceptable prior to approval of future phases. This will involve monitoring of groundwater and/or surface water quality and/or other potential receptors noted above. Wells will be required downgradient of the development for ongoing groundwater monitoring. It is recognized that several years may be required to develop plumes. The proposed monitoring programme will address:

- rationale for location of the proposed monitoring well, for example, direction of groundwater flow, contaminant sources, etc.;
- source of water supply (ie communal vs individual wells);
- zone(s) to be monitored (ie depth of well, aquifer receiving effluent, aquifer supplying water, receptors).
- chemical and other parameters to be monitored (eg. nitrate, bacteria)

The monitoring wells will be monitored for water quality and water levels quarterly for the first year to establish baseline conditions and, semi-annually until the Region assumes responsibility for water supply to the development. Semi annual monitoring should be done during high base flow (spring) and low baseflow (late summer) conditions.

The monitoring well(s) will be constructed in general accordance with Figure 1. Where site specific conditions require modification to the typical arrangement, the developer will provide details for Regional approval.

Monitoring results will be provided to the Region's Engineering Department within 30 days of completion.

The location of all monitoring and supply wells shall be documented by Universal Transverse Mercator (UTM) Co-ordinates and shown on a site plan. Borehole records and well logs shall be supplied for each well.

Applicable

1) Interim guidelines for the preparation of Servicing Studies, Ontario Ministry of the Environment.

APPENDIX K
GLOSSARY
(After Fetter 1988)

Adsorption - The attraction and adhesion of a layer of ions from an aqueous solution to the solid mineral surfaces with which it is in contact.

Advection - The process by which solutes are transported by the motion of flowing ground water.

Anisotropy - The condition under which one or more of the hydraulic properties of an aquifer vary according to the direction of flow.

Aquiclude - A low-permeability unit that forms either the or lower boundary of a ground-water flow system.

Aquifer - Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit economic quantities of water to wells and springs.

Aquifer, confined - An aquifer that is overlain by a confining bed. The confining bed has a significantly lower hydraulic conductivity than the aquifer.

Aquifer, perched - A region in the unsaturated zone where the soil may be locally saturated because it overlies a low-permeability unit.

Aquifer, semiconfined - An aquifer confined by a low-permeability layer that permits water to slowly flow through it. During pumping of the aquifer, recharge to the aquifer can occur across the confining layer. Also known as a leaky artesian or leaky confined aquifer.

Aquifer test - See pumping test.

Aquifer, unconfined - An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer. Water-table aquifer is a synonym.

Aquitard - A low-permeability unit that can store ground water and also transmit it slowly from one aquifer to another.

Artificial recharge - The process by which water can be injected or added to an aquifer. Dug basins, drilled wells, or simply the spread of water across the land surface are all means of artificial recharge.

Baseflow - That part of stream discharge from ground water seeping into the stream.

Baseflow recession - The declining rate of discharge of a stream fed only by baseflow for an extended period. Typically, a baseflow recession will be exponential.

Baseflow-recession hydrograph - A hydrograph that shows a baseflow-recession curve.

Borehole geophysics - The general field of geophysics developed around the lowering of various probes into a well.

Boring - A hole advanced into the ground by means of a drilling rig.

Casing - See well casing.

Cation exchange capacity - The ability of a particular rock or soil to absorb cations.

Cementation - The process by which some of the voids in a sediment are filled with precipitated materials, such as silica, calcite, and iron oxide, and which is a part of diagenesis.

Chemical activity - The molal concentration of an ion multiplied by a factor known as the activity coefficient.

Contaminant - See pollutant.

Diffusion - The process by which both ionic and molecular species dissolved in water move from areas of higher concentration to areas of lower concentration.

Digital computer model - A model of ground-water flow in which the aquifer is described by numerical equations, with specified values for boundary conditions, that are solved on a digital computer.

Discharge - The Volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.

Discharge area - An area in which there are upward components of hydraulic head in the aquifer. Ground water is flowing toward the surface in a discharge area and may escape as a spring, seep, or baseflow or by evaporation and transpiration.

Dispersion - The phenomenon by which a solute in flowing ground water is mixed with uncontaminated water and becomes reduced in concentration. Dispersion is caused by both differences in the velocity that the water travels at the pore level and differences in the rate at which water travels through different strata in the flow path.

Drainage Basin - The land area from which surface runoff drains into a stream system.

Drainage divide - A boundary line along a topographically high area that separates two adjacent drainage basins.

Drawdown - A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of ground water from wells.

Effective grain size - The grain size corresponding to the 10 percent finer by weight line on the grain-size distribution curve.

Effective pore fraction - The ratio of the porosity available for fluid flow to the total porosity of a rock or sediment.

Effective porosity - See porosity, effective.

Equipotential line - A line in a two-dimensional ground-water flow field such that the total hydraulic head is the same for all points along the line.

Equipotential surface - A surface in a three-dimensional ground-water flow field such that the total hydraulic head is the same everywhere on the surface.

Finite-difference model - A particular kind of a digital computer model based upon a rectangular grid that sets the boundaries of the model and the nodes where the model will be solved.

Finite-element model - A digital ground-water-flow model where the aquifer is divided into a mesh formed of a number of polygonal cells.

Glacial-lacustrine sediments - Silt and clay deposits formed in the quiet waters of lakes that received meltwater from glaciers.

Glacial outwash - Well-sorted sand, or sand and gravel, deposited by the meltwater from a glacier.

Glacial till - A glacial deposit composed of mostly unsorted sand, silt, clay, and boulders and laid down directly by the melting ice.

Ground water, confined - The water contained in a confined aquifer. Pore-water pressure is greater than atmospheric at the top of the confined aquifer.

Ground water drainage basin - A rather vague designation pertaining to a groundwater reservoir that is more of less separate from neighbouring ground water reservoirs. A ground water basin could be separated from adjacent basins by geologic boundaries or hydrologic boundaries.

Ground-water flow - The movement of water through openings is sediment and rock; occurs in the zone of saturation.

Ground-water mining - The practice of withdrawing ground water at rates in excess of the natural recharge.

Ground water, perched - The water in an isolated, saturated zone located in the zone of aeration. It is the result of the presence of a layer of material of low hydraulic conductivity, called a perching bed. Perched ground water will have a perched water table.

Ground water, unconfined - The water in an aquifer where there is a water table.

Guelph permeameter - See permeameter.

Hardness - A measure of the amount of calcium, magnesium, and iron dissolved in the water.

Head, total - The sum of the elevation head, the pressure head, and the velocity head at a given point in an aquifer.

Heterogeneous - Pertaining to a substance having different characteristics in different locations. A synonym is non uniform.

Homogeneous - Pertaining to a substance having identical characteristics everywhere. A synonym is uniform.

Hydraulic gradient - The change in total head with a change in distance in a given direction. The direction is that which yields a maximum rate of decrease in head.

Hydraulic Mounding - The head differential generated between the point of injection and the water table at some distance from the bed. This head differential is referred to as ground water mound.

Hydrogeology - The study of the interrelationships of geologic materials and processes with water, especially ground water.

Hydrograph - A graph that shows some property of ground water or surface water as a function of time.

Hydrostratigraphic unit - A formation, part of a formation, or group of formations in which there are similar hydrologic characteristics allowing for grouping into aquifers or confining layers.

Infiltration - The flow of water downward from the land surface into and through the upper soil layers.

Infiltration capacity - The maximum rate at which infiltration can occur under specific conditions of soil moisture. For a given soil, the infiltration capacity is a function of the water content.

Isotropy - The condition in which hydraulic properties of the aquifer are equal in all directions.

Leaky confining layer - A low-permeability layer that can transmit water at sufficient rates to furnish some recharge to a well pumping from an underlying aquifer. Also call aquitard.

Milligrams per liter - A measure of the amount of dissolved solids in a solute in terms of milligrams of solute per liter of solution.

Model calibration - The process by which the independent variables of a digital computer model are varied in order to calibrate a dependent variable such as a head against a known value such as a water-table map.

Model field verification - The process by which a digital computer model that has been calibrated and verified is tested to see if it can predict the field response of an aquifer to some transient condition.

Model verification - The process by which a digital computer model that has been calibrated against a steady-state condition is tested to see if it can generate a transient response, such as the decline in the water table with pumping, that matches the known history of the aquifer.

Observation well - A nonpumping well used to observe the elevation of the water table or the potentiometric surface. An observation well is generally of large diameter than a piezometer and typically is screened or slotted throughout the thickness of the aquifer.

Permeameter - A laboratory device used to measure the intrinsic permeability and hydraulic conductivity of a soil or rock sample.

Piezometer - A non pumping well, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface. A piezometer generally has a short well screen through which water can enter.

Pollutant - Any solute or cause of change in physical properties that renders water unfit for a given use.

Pore space - The volume between mineral grains in a porous medium.

Porosity - The ratio of the volume of void spaces ina rock or sediment to the total volume of the rock or sediment.

Potentiometric map - A countour map of the potentiometric surface of a particular hydrogeologic unit.

Potentiometric surface - A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.

Pumping cone - The area around a discharging well where the hydraulic head in the aquifer has been lowered by pumping. Also called cone of depression.

Pumping test - A test made by pumping a well for a period of time and observing the change in hydraulic head in the aquifer. A pumping test may be used to determine the capacity of the well and the hydraulic characteristics of the aquifer. Also called aquifer test.

Recharge area - An area in which there are downward components of hydraulic head in the aquifer. Infiltration move downward into the deeper parts of an aquifer in a recharge area.

Recharge basin - A basin or pit excavated to provide a means of allowing water to soak into the ground at rates exceeding those that would occur naturally.

Recharge boundary - An aquifer system boundary that adds water to the aquifer. Streams and lakes are typically recharge boundaries.

Recovery - The rate at which the water level in a well rises after the pump has been shut off. It is the reverse of drawdown.

Rock, igneous - A rock formed by the cooling and crystallization of a molten rock mass call magma.

Rock, metamorphic - A rock formed by the application of heat and pressure to preexisting rocks.

Rock, plutonic - An igneous rock formed when magma cools and crystallizes within the earth.

Rock, sedimentary - A rock formed from sediments, through a process known as diagenesis or formed by chemical precipitation in water.

Rock, volcanic - An igneous rock formed when molten rock called lava cools on the earth's surface.

Runoff - The total amount of water flowing in a stream. It includes overland flow, return flow, interflow, and base flow.

Saturated zone - The zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric. The water table is the top of the saturated zone in an unconfined aquifer.

Storativity - The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. It is equal to the product of specific storage and aquifer thickness. In an unconfined aquifer, the storativity is equivalent to the specific yield. Also called storage coefficient.

Throughflow - The lateral movement of water in an unsaturated zone during and immediately after a precipitation event. The water from throughflow seeps out at the base of slopes and then flows across the ground surface as return flow, ultimately reaching a stream or lake.

Transmissivity - The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media.

Turbidity - Cloudiness in water due to suspended and colloidal organic and inorganic material.

Unsaturated zone - The zone between the land surface and the water table. It includes the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure, as well as air and other gases. Saturated bodies, such as perched ground water, may exist in the unsaturated zone. Also called zone of aeration and vadose zone.

Volatile organic compound (VOC) - An organic compound that is characterized by being highly mobile in ground water and which is readily volatilized into the atmosphere.

Water budget - An evaluation of all the sources of supply and the corresponding discharges with respect to an aquifer or drainage basin.

Water table - The surface in an unconfined aquifer or confining bed at which the pore water pressure is atmospheric. It can be measured by installing shallow wells extending a few feet into the zone of saturation and then measuring the water level in those wells.

Well casing - A solid piece of pipe, typically steel or PVC plastic, used to keep a well open in either unconsolidated materials or unstable rock.

Well development - The process where by a well is pumped or surged to remove any fine material that may be blocking the well screen or the aquifer outside the well screen.

Well, fully penetrating - A well drilled to the bottom of an aquifer, constructed in such a way that it withdraws water from the entire thickness of the aquifer.

Well interference - The result of two or more pumping wells, the drawdown cones of which intercept. At a given location, the total well interference is the sum of the drawdowns due to each individual well.

Well, partially penetrating - A well constructed in such a way that it draws water directly from a fractional part of the total thickness of the aquifer. The fractional part may be located at the top or the bottom or anywhere in between in the aquifer.

Well screen - A tubular device with either slots, holes, gauze, or continous-wire wrap; used at the end of a well casing to complete a well. The water enters the well through the well screen.

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